Proposed

Total Maximum Daily Load

for

Nutrients, Dissolved Oxygen and Biochemical Oxygen Demand

in

Six Mile Creek/Tampa Bypass Canal (WBIDs 1536F and 1536B)

November 2012

Region 4 serving the southeast

Table of Contents

Table of Figures

Table of Tables

LIST OF ABBREVIATIONS

B-MAP	Basin Management Action Plan
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CO_2	Carbon Dioxide
DO	Dissolved Oxygen
EMC	Event Mean Concentration
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FLUCCS	Florida Land Use Cover Classification System
FS	Florida Statutes
GIS	Geographic Information System
HSPF	Hydrologic Simulation Program Fortan
HUC	Hydrologic Unit Code
IWR	Impaired Surface Waters Rule
KM^2	Square Kilometers
L	Liters
L/FT^3	Liters per Cubic Foot
LA	Load Allocation
LB/YR	Pounds per year
LSPC	Loading Simulation Program C++
MGD	Million Gallons per Day
MG/L	Milligram per liter
ML	Milliliters
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems
NASS	National Agriculture Statistics Service
NH_4	Ammonia Nitrogen
NHD	National Hydrography Data
NO_2	Nitrite
NO_3	Nitrate
NPDES	National Pollutant Discharge Elimination System
OBS	Observations

OSTD	Onsite Treatment and Disposal System
SCI	Stream Condition Index
SWFWMD	Southwest Florida Water Management District
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WASP	Water Quality Analysis Simulation Program
WBID	Water Body Identification
WLA	Waste Load Allocation
WQS	Water Quality Standards
WMD	Water Management District
WWTP	Waste Water Treatment Plant

SUMMARY SHEET
Total Maximum Daily Load (TMDL)

1998 303(d) Listed Waterbody for TMDL addressed in this report:

WBIDs	Segment Name	Class and Waterbody Type	Major River Basin	HUC	County	State
1536F, 1536B	Six Mile Creek	Class III freshwater	Tampa Bay Basin	03100206	Hillsborough	Florida

TMDL Endpoints/Targets:

Dissolved Oxygen and Nutrients

TMDL Technical Approach:

Current nutrient levels in Six Mile Creek were compared to various instream targets, and also to the loads identified as necessary to protect against adverse water quality impacts downstream. The final TMDL allocations were set to ensure that pollutant loadings from the Six Mile Creek watershed would not cause or contribute to nutrient or dissolved oxygen impairment in the receiving waters. Watershed loads developed for the Nitrogen Management Consortium Reasonable Assurance Plan were used to predict both current and natural pollutant loadings. An EFDC hydrodynamic model was used to simulate water movement, and a WASP Eutrophication model was used to evaluate the in-stream impacts of the current and natural pollutant loading scenarios, and determine whether they would meet water quality standards.

TMDL Waste Load and Load Allocation

	Current Condition		TMDL Condition		
Constituent	**Facility WLA (lb/yr)**	**MS4/LA (lb/yr)**	**Facility WLA (lb/yr)**	**MS4/LA (lb/yr)**	**Percent Reduction**
Total Nitrogen	NA	212,495	NA	43,847	79%
Total Phosphorus	NA	66,477	NA	15,221	77%
BOD	NA	496,457	NA	150,399	70%

Endangered Species Present (Yes or Blank):

USEPA Lead TMDL (USEPA or Blank): USEPA

TMDL Considers Point Source, Non-point Source, or Both: Both

Major NPDES Discharges to surface waters addressed in USEPA TMDL:

Permit	Permittee	County	Permit Type
FLS000006	Hillborough County, FDOT District 7, and co-permittees	Hillsborough	Phase I MS4
FLS000008	City of Tampa, FL	Hillsborough	Phase I MS4
FLS000009	City of Temple Terrace, FL	Hillsborough	Phase I MS4

1. Introduction

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology-based effluent limitations are not stringent enough to protect all water quality standards applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not meeting water quality standards. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (USEPA, 1991).

The Florida Department of Environmental Protection (FDEP) developed a statewide, watershed-based approach to water resource management in the state. Under the watershed management approach, water resources are managed on the basis of natural boundaries, such as river basins, rather than political boundaries. The state's 52 basins are divided into five groups and water quality is assessed in each group on a rotating five-year cycle. The watershed management approach is the framework FDEP uses for implementing TMDLs. FDEP also established five water management districts (WMD) responsible for managing ground and surface water supplies in the counties encompassing the districts. The subject of this report, Six Mile Creek, is located in the Tampa Bay Basin and is a Group 1 waterbody managed by the Southwest Florida Water Management District (SWFWMD).

For the purpose of planning and management, the WMDs divided the district into planning units defined as either an individual primary tributary basin or a group of adjacent primary tributary basins with similar characteristics. These planning units contain smaller, hydrological based units called drainage basins, which are further divided by FDEP into "water segments". A water segment usually contains only one unique waterbody type (stream, lake, canal, etc.) and is about five square miles. Unique waterbody identification numbers (WBIDs) are assigned to each water segment. This TMDL report addresses WBIDs 1536B and 1536F within the Coastal Hillsborough Bay Planning Unit. These WBIDs encompass the freshwater portion of Six Mile Creek, otherwise known as the Tampa Bypass Canal. Six Mile Creek flows directly into the tidal Palm River, which empties into McKay Bay, then East Bay and, ultimately, into Hillsborough Bay (Figure 1).

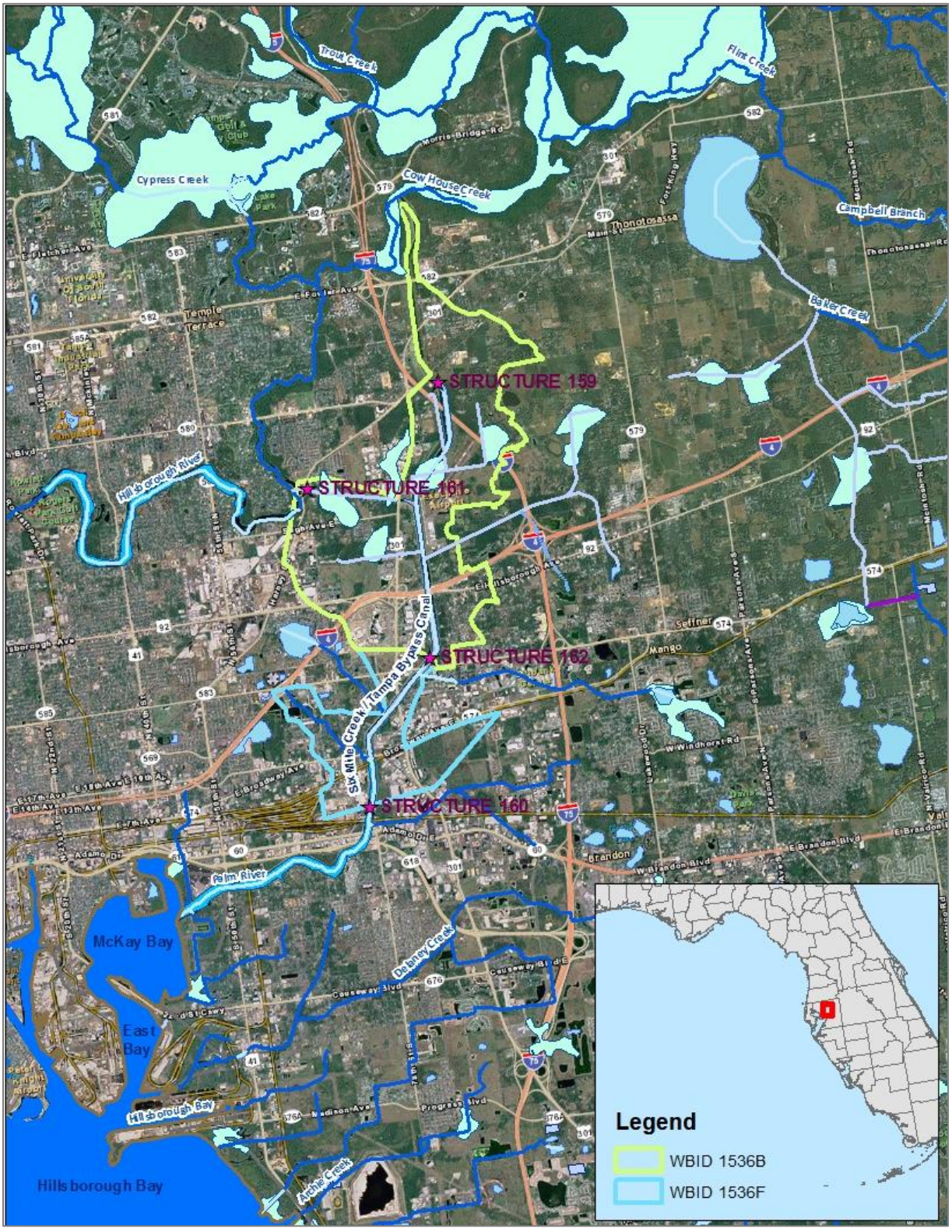

Figure 1. Location of Six Mile Creek (Tampa Bypass Canal) WBIDs 1536F and 1536B.

2. Problem Definition

To determine the status of surface water quality in Florida, three categories of data – chemistry data, biological data, and fish consumption advisories – were evaluated to determine potential impairments. The level of impairment is defined in the Identification of Impaired Surface Waters Rule (IWR), Section 62-303 of the Florida Administrative Code (FAC). The IWR is FDEP's methodology for determining whether waters should be included on the state's planning list and verified list. Potential impairments are determined by assessing whether a waterbody meets the criteria for inclusion on the planning list. Once a waterbody is on the planning list, additional data and information are collected and examined to determine if the water should be included on the verified list. The IWR defines the thresholds for determining if waters should be placed on the state's planning and verified lists. WBID 1536B of Six Mile Creek was verified for dissolved oxygen impairment due to nutrients and biochemical oxygen demand (BOD) as part of the assessments to develop the 2004 303(d) list. In 2009, WBID 1536F of Six Mile Creek and tributary WBID 1536C, were verified by FDEP as impaired for nutrients and dissolved oxygen.

The TMDLs addressed in this document are being proposed pursuant to commitments made by the United States Environmental Protection Agency (USEPA) in the 1998 Consent Decree ordered in the Florida TMDL lawsuit (Florida Wildlife Federation, et al. v. Carol Browner, et al., Civil Action No. 4: 98CV356-WS, 1998). That Consent Decree established a schedule for TMDL development for waters listed on Florida's USEPA approved 1998 section 303(d) list. The 1998 section 303(d) list identified numerous WBIDs in the Tampa Bay Basin, including Six Mile Creek/Tampa Bypass Canal, one of its main tributaries (WBID 1536C), and its downstream receiving waters (Palm River WBID 1536E and McKay Bay WBID 1584B) as waterbodies that were not meeting one or more of their applicable water quality standards. A TMDL to address nutrient and dissolved oxygen impairment in the Tampa Bypass Canal Tributary (WBID 1536C) was established by EPA in February 2012, and TMDLs to address dissolved oxygen and nutrient impairment in the Palm River and McKay Bay were proposed by EPA in June 2012. After assessing all readily available water quality data, USEPA is responsible for developing TMDLs to address dissolved oxygen, nutrients, and BOD in WBIDs 1536B and 1536F of Six Mile Creek (Tampa Bypass Canal).

3. Watershed Description

Six Mile Creek is the original name of a stream located east of the Hillsborough River in Hillsborough County, Florida. Historically, the shallow stream drained approximately 40 square miles of pine, oak, and palm forest, meandering south and then westward before draining into the Palm River and McKay Bay (Foley, 2007). In 1960, after a particularly wet year and a series of tropical storms and hurricanes that resulted in extensive flooding throughout Florida, local residents demanded that something be done to minimize flooding for the rapidly growing populations of Tampa, Temple Terrace, and other cities. The following year, in 1961, the Southwest Florida Water Management District (SWFWMD) was created in order to manage, regulate, and protect water resources in the region.

Between 1966 and 1981, the U.S. Army Corps of Engineers dredged, widened, straightened and armored Six Mile Creek, and created canals artificially connecting it to the Hillsborough River. The goal of these efforts was to divert floodwaters from the urbanized areas along the Hillsborough River to the Six Mile Creek/Palm River system. Six Mile Creek is typically referred to as the Tampa Bypass Canal, reflecting its new function and the significant physical alterations that have occurred in the watershed.

The present day Six Mile Creek is a 500-600 foot-wide, 20 foot-deep canal that is armored along its length. Water flow through the system is controlled by a series of structures, each of which has multiple vertical lift gates that seat on the crest of a weir (SWFWMD, 2005). S-161 allows water to be diverted from the Hillsborough River via the Harney Canal (Figure 1). The freshwater portion of Six Mile Creek is divided into upper, middle and lower pools by structures S-159, S-162, and S-160, respectively (Figure 1). S-160 also controls freshwater inflow to the tidal portion of the canal, known as the Palm River. Year-round algal blooms have been noted in the Palm River (Foley, 2007), and chronically low oxygen levels have been documented in McKay Bay (SWFWMD, 2005). In fact, both the Palm River (WBID 1536E) and McKay Bay (WBID 1584B) have been verified as impaired for nutrients and dissolved oxygen.

Since dredging the Tampa Bypass Canal to 20 feet breached the underlying artesian Floridan aquifer in several locations, the water levels within each pool are managed to reduce impacts to groundwater. Water from the pools can also be pumped from the middle and lower pools of the Tampa Bypass Canal (Six Mile Creek) and used to augment the Tampa Reservoir during dry conditions.

WBID 1536F of Six Mile Creek is defined on its upstream and downstream ends by S-162 and S-160, respectively. Flow through WBID 1536B of Six Mile Creek is defined by S-161, S-159 and S-162. The watershed draining to these WBIDs is estimated to be over 18,000 acres, although the area draining to the canal increases dramatically whenever water from the Hillsborough River is diverted to it.

In order to identify possible pollutant sources in the watershed, the latest land use coverage was obtained from FDEP and the SWFWMD. Land use data are based on 2009 land cover features categorized according to the Florida Land Use and Cover Classification System (FLUCCS). Table 1, Figure 2 and Figure 3 show that land use in the Six Mile Creek watershed is predominantly developed, with approximately 65 percent classified as urban or residential uses. Another eight percent of the watershed area is used for transportation, communication, or utilities, reflecting the presence of the Tampa Executive Airport and the fact that Interstates 75 and 4 traverse the watershed. About 7 percent of the area is classified as agriculture, while wetlands and open water constitute approximately 10 and 5 percent, respectively. Only about five percent of the watershed remains as forest. Since there are no permitted wastewater or industrial facilities draining to the freshwater portion of Six Mile Creek, and since the watershed is highly developed, stormwater runoff from urban and suburban areas is considered to be the major contributor of the pollutants that may cause or contribute to the dissolved oxygen impairment.

Table 1. Landuse distribution in the Six Mile Creek Watershed.

Watershed	Urban, Residential & Built-Up	Agriculture	Rangeland	Forest	Water	Wetlands	Barren Land	Transportation, Communication & Utilities	Total
FLUCCS Code Level 1 Series[1]	1000[2]	2000	3000[3]	4000	5000	6000	7000	8000	
acres	11,704	1,247	23	874	965	1,783	12	1,399	18,007
percent	65%	7%	0%	5%	5%	10%	0%	8%	100%
WBID 1536B									
FLUCCS Code[1]	1000[2]	2000	3000[3]	4000	5000	6000	7000	8000	
acres	2,625	321	11	343	392	749	12	520	4,973
percent	53%	6%	0%	7%	8%	15%	0%	10%	100%
WBID 1536F									
FLUCCS Code[1]	1000[2]	2000	3000[3]	4000	5000	6000	7000	8000	
acres	1,380	0	12	38	144	43	0	72	1,689
percent	82%	0%	1%	2%	9%	3%	0%	4%	100%

1. Land use data are based on 2009 land cover features categorized according to the SWFWMD's modified Florida Land Use and Cover Classification System (FLUCCS). The features were photointerpreted from 2009 color infrared and digital aerial photographs at the 1:8,000 scale.
2. The urban/residential/built-up category includes commercial, industrial, extractive, institutional, and recreational uses.
3. The rangeland category includes dry prairies, shrub and brushland and mixed rangeland.

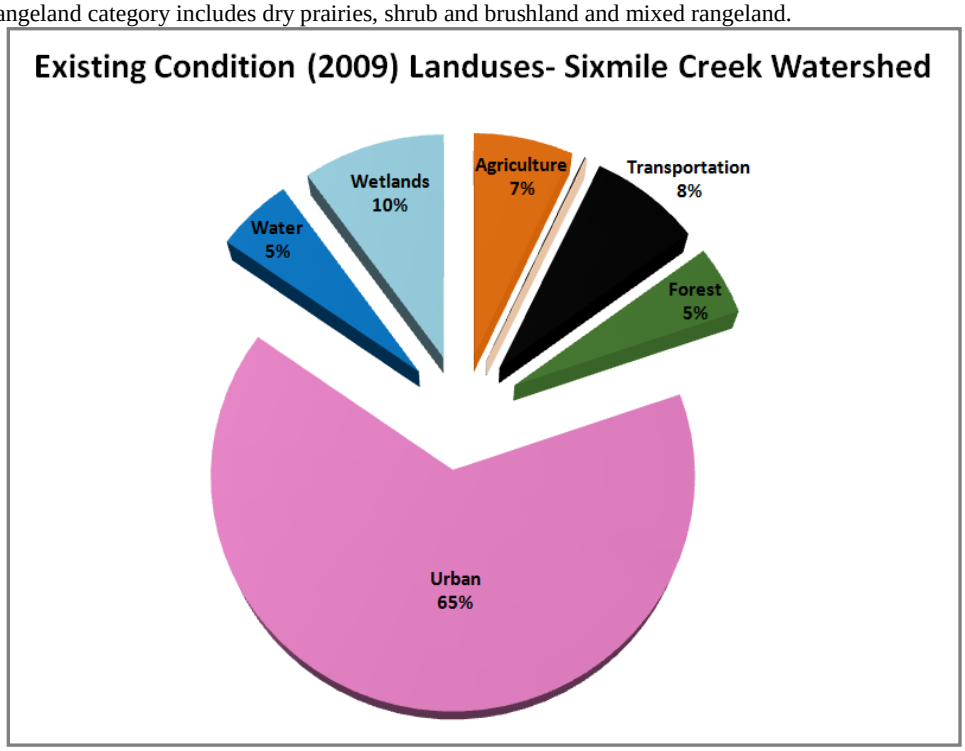

Figure 2. Current (2009) Landuse Percentages in the Six Mile Creek Watershed.

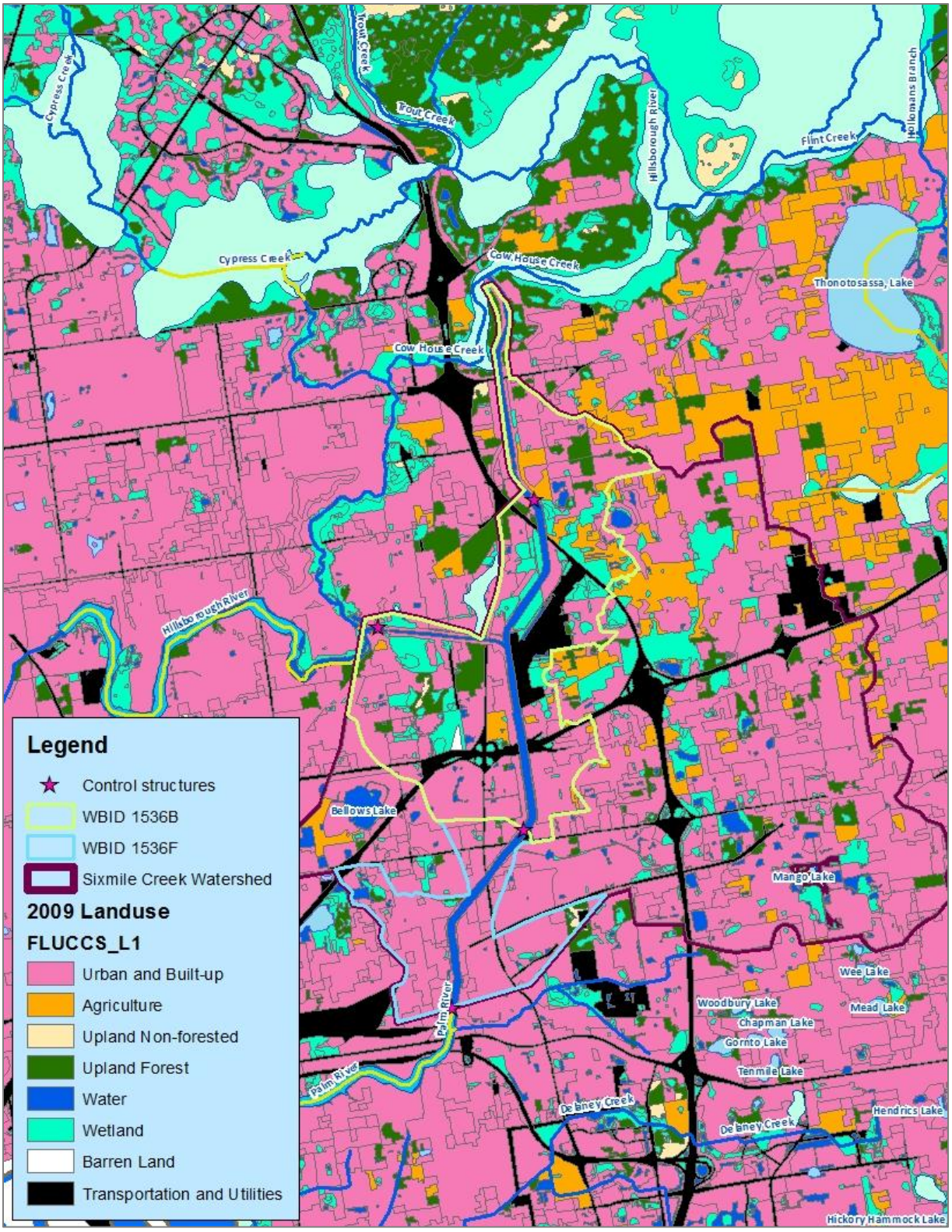

Figure 3. Land use in the Six Mile Creek Watershed.

4. Water Quality Standards/TMDL Targets

Six Mile Creek (WBIDs 1536F and 1536B), also known as the Tampa Bypass Canal, is currently categorized as a Class III Freshwater, with designated uses that include Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife. The water quality criteria for protection of Class III waters are established by the State of Florida in the Florida Administrative Code (FAC), Section 62-302.530. The individual criteria should be considered in conjunction with other provisions in water quality standards that apply to all waters, including Section 62-302.500 FAC [Surface Waters: Minimum Criteria, General Criteria], unless alternative or more stringent criteria are specified in FAC Section 62-302.530. In addition, unless otherwise stated, all criteria express the maximum not to be exceeded at any time. The specific criteria addressed in this TMDL document are provided in the following section.

4.1. Nutrients Criteria:

In 1979, FDEP adopted narrative criteria for nutrients, which are described further in section 4.4.1. FDEP recently adopted numeric nutrient criteria for many Class III waters in the state, including streams, which numerically interpret part of the state narrative nutrient criteria. Those criteria have been submitted to EPA for review pursuant to section 303(c) of the CWA; however, EPA has not completed its review. Therefore, for streams in Florida, the applicable nutrient water quality standard for CWA purposes remains the Class III narrative criteria. Should any new or revised state criteria for nutrients in Florida streams become applicable for CWA purposes before this proposed TMDL is established, EPA will consider the impact of such criteria on the target selected for this TMDL.

In November 2010, EPA promulgated numeric nutrient criteria for Class III inland waters in Florida, including streams. On February 18, 2012, the streams criteria were invalidated by the U.S. District Court for the Northern District of Florida and remanded back to EPA. Should federally promulgated criteria become effective for CWA purposes before this proposed TMDL is established, EPA will consider the impact of those criteria on the targets selected for this TMDL.

4.1.1. Narrative Nutrient Criteria

The State of Florida's narrative water quality criterion for nutrients applies to Classes I, II, and III (including fresh and marine waters) and states that:

> "In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna." [Section 62.302.530 (48)(b) FAC]

The state also has an additional narrative water quality criterion for nutrients that applies to all classes of water and states that:

> "The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. Man-induced nutrient enrichment (total nitrogen or total phosphorus) shall be considered degradation in relation to the provisions of Sections 62-302.300, 62-302.700, and 62-4.242, FAC." [see Section 62.302.530 (48)(a) FAC]

Chlorophyll and dissolved oxygen (DO) levels are commonly used to indicate whether nutrients are present in excessive amounts. The target for this TMDL is based on an analysis of the levels of nutrients necessary to prevent violations of Florida's DO criterion, which is described below, in Section 4.2.

4.1.2. Florida's Adopted Numeric Nutrient Criteria for Rivers and Streams

Florida's recently adopted nutrient criteria numerically interpret the narrative water quality criteria in paragraph 62-302.530(48)(b), F.A.C. (See section 62-302.531(2).) The Florida rule provides that the narrative water quality criteria for nutrients in paragraph 62-302.530(47)(a), F.A.C., continue to apply to all Class III waters. (See section 62-302.531(1).)

Florida's recently adopted rule applies to streams, including Six Mile Creek. For streams that do not have site-specific criteria, Florida's rule states that biological information will be considered together with nutrient thresholds to determine whether a waterbody is attaining the standards described in 62-302.531(2)(c), F.A.C. The rule provides that the nutrient criteria are attained in a stream segment where information on chlorophyll-*a* levels, algal mats or blooms, nuisance macrophyte growth, and changes in algal species composition indicates that there are no imbalances in flora and either the average score of at least two temporally independent Stream Condition Index (SCI) tests performed at representative locations and times is 40 or higher, with neither of the two most recent SCI scores less than 35, or the nutrient thresholds set forth in Table 2 below are achieved. (See section 62-302.531(2)(c).) The SCI test is a primary indicator for ecosystem health and can be used to identify impairment with respect to a reference condition. Seven benthic (bottom-dwelling) macroinvertebrate metrics are used which measure diversity, composition, and functional feeding group representation, and provide information on the pollution tolerance of the species present. The information from these metrics is combined to generate a Stream Condition Index (SCI) for Florida.

The adopted numeric nutrient criteria in Table 2 are expressed as geometric mean concentrations that should not be exceeded more than once in any three calendar year period (Section 62-302.200 (25)(e), F.A.C.).

Should FDEP's numeric nutrient criteria for streams become an applicable water quality standard for CWA purposes before this TMDL is established, EPA will consider the nutrient target necessary to attain section 62-302.531(2)(c), F.A.C. EPA will compare that target with the target necessary to attain paragraph 62-302.530(47)(a), F.A.C., in order to determine which target is more stringent.

Table 2. Inland Numeric Nutrient Criteria.

Nutrient Watershed Region	Total Phosphorus Nutrient Threshold	Total Nitrogen Nutrient Threshold
Panhandle West	0.06 mg/L	0.67 mg/L
Panhandle East	0.18 mg/L	1.03 mg/L
North Central	0.30 mg/L	1.87 mg/L
Peninsular	0.12 mg/L	1.54 mg/L
West Central	0.49 mg/L	1.65 mg/L
South Florida	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.

4.2. Dissolved Oxygen Criteria:

Numeric criteria for DO are expressed in terms of minimum and daily average concentrations. The water quality criteria for dissolved oxygen in Class III Freshwaters are as follows:

> "Shall not be less than 5.0 mg/L. Normal daily and seasonal fluctuations above these levels shall be maintained." [FAC 62-302.530 (31)]

4.3. Biochemical Oxygen Demand Criteria:

The applicable water quality criterion for biochemical oxygen demand is a narrative related to the impact on dissolved oxygen:

> "Biochemical Oxygen Demand (BOD) shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case, shall it be great enough to produce nuisance conditions." [FAC 62-302.530 (11)]

4.4. Natural Conditions

In addition to the standards for nutrients, DO, and BOD described above, Florida's standards include provisions that address waterbodies which do not meet the standards due to natural background conditions.

Florida's water quality standards provide the following definition of natural background:

> "Natural Background" shall mean the condition of waters in the absence of man-induced alterations based on the best scientific information available to the Department. The establishment of natural background for an altered waterbody may be based upon a similar unaltered waterbody or on historical pre-alteration data. [FAC 62-302.200(16)]

Florida's water quality standards also provide that:

> "Pollution which causes or contributes to new violations of water quality standards or to continuation of existing violations is harmful to the waters of this State and shall not be allowed. Waters having water quality below the criteria established for them shall be protected and enhanced. However, the Department shall not strive to abate natural conditions." [FAC 62-302.300(15)]

5. Water Quality Assessment

The area encompassed by WBIDs 1536F and 1536B of Six Mile Creek was identified on Florida's 1998 303(d) list for not attaining its designated uses due to dissolved oxygen, biochemical oxygen demand and nutrients. To verify the current water quality status of WBIDs 1536F and 1536B, EPA conducted a water quality assessment using current water quality data. The data were obtained from Version 44 of FDEP's IWR database, and the primary constituents evaluated were: dissolved oxygen, biochemical oxygen demand, chlorophyll-*a*, and nutrients. The IWR database contains data from various sources within the state of Florida, including the Water Management Districts and counties.

5.1. Water Quality Data

The tables and figures below present the station locations and time series data for dissolved oxygen, biochemical oxygen demand, total nitrogen, total phosphorus, and chlorophyll-*a* observations in Six Mile Creek. Summary statistics for the water quality data are provided within each figure. The original data are included in the Administrative Record for this report, and are also available upon request.

5.1.1. WBID 1536F: Six Mile Creek

Table 3 identifies monitoring stations located in WBID 1536F and lists the time period over which water quality measurements were made at each location during the assessment period for IWR Version 44. Figure 4 illustrates where these monitoring stations are located. Stations 21FLHILL147 and 21FLTPA275854508221188 are essentially situated in the same location, just downstream of structure S-162. Stations 21FLTBWPRDAM000 and 21FLTPA 275758908222021 are located toward the downstream end of WBID 1536F, upstream of structure S-160. Station 21FLWQSPHIL591CA is situated in between these two locations.

Table 3. Water Quality Monitoring Stations for WBID 1536F: Six Mile Creek.

Station	Station Name	First Date	Last Date	No. Obs
21FLHILL147	Tampa Bypass Canal at north side of MLK Blvd.	07/15/2003	12/13/2010	1425*
21FLTPA 275854508221188	TP 433 - Six Mile Creek	02/21/2006	11/28/2006	141
21FLWQSPHIL591CA	Tampa Bypass Canal in Vetrans Memorial Park (WBID 1536F)	03/18/2005	12/06/2005	240
21FLTBW PRDAM000	Tampa_Bay_Palm_Dam_PRDAM000	07/29/2003	08/18/2010	189
21FLTPA 275758908222021	TP434 - Six Mile Cr.	04/03/2006	11/28/2006	78

NOTES: No. Obs.= Number of observations (various parameters) in IWR 44 current assessment period. *One value for total nitrogen, sampled at station 21FLHILL147 on 4/19/05, was removed from the dataset as an outlier.

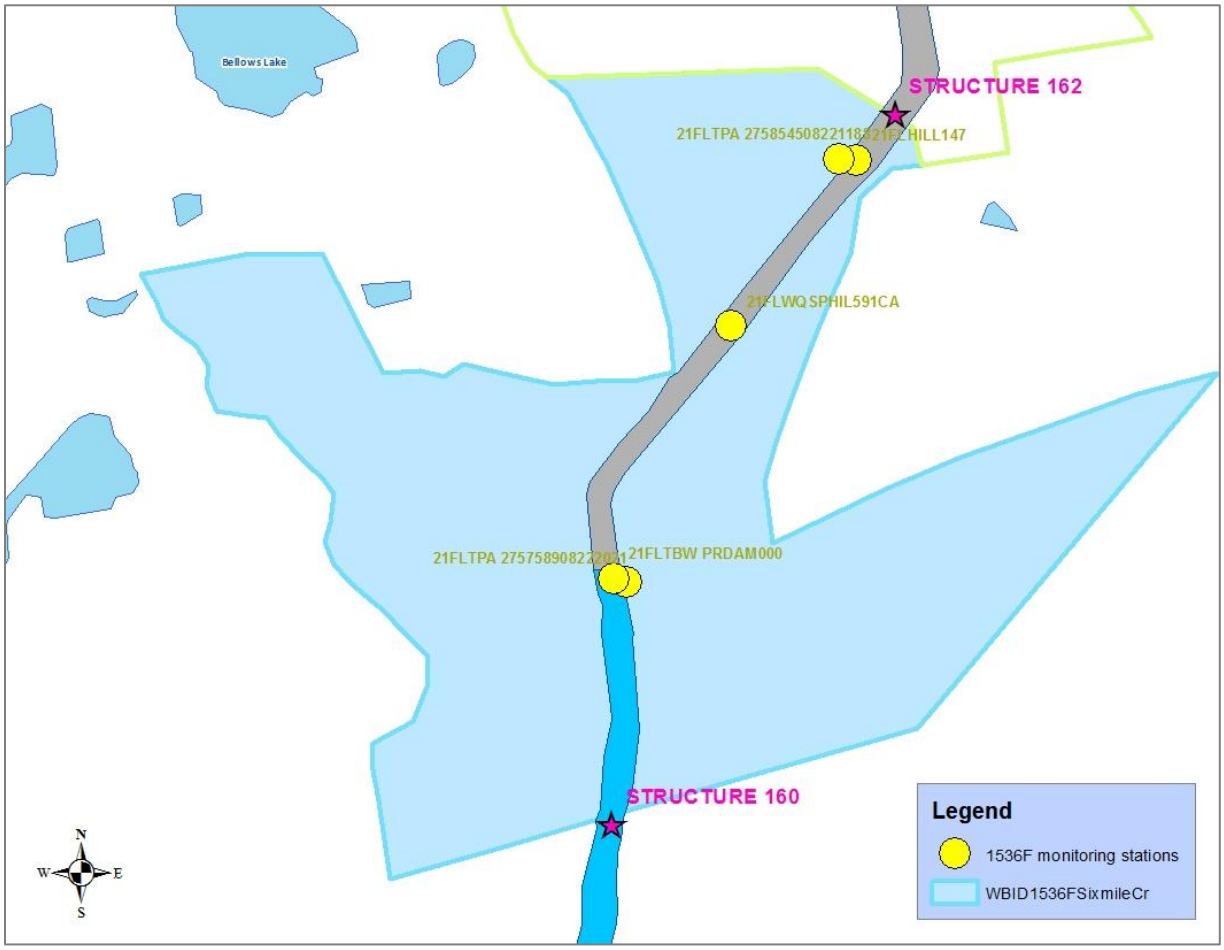

Figure 4. Location of Monitoring Stations in WBID 1536F of Six Mile Creek.

Dissolved Oxygen

There are several factors that affect the concentration of dissolved oxygen in a waterbody. Oxygen can be introduced by wind, diffusion, photosynthesis, and additions of higher DO water (e.g. from tributaries). DO concentrations are lowered by processes that use up oxygen from the water, such as respiration and decomposition, and by additions of water with lower DO (e.g. swamp or groundwater). Natural DO levels are a function of water temperature, water depth and velocity, as well as the relative contributions of groundwater. However, the natural DO regime may be impacted by pollutants such as nutrients and oxygen-demanding substances. Replenishment of oxygen levels may be inhibited if excessive growth of aquatic plants above the water surface blocks sunlight from reaching submerged vegetation, reducing their ability to photosynthesize. Decomposition of organic matter, such as dead plants and animals, also uses up DO from the water.

Nutrient levels affect DO concentrations directly and indirectly. The process of nitrification, in which bacteria convert ammonia-nitrogen to nitrate-nitrogen, directly consumes oxygen from the water. Excessive nutrient loading indirectly affects DO due to over-stimulation of aquatic plant growth, which leads to exacerbated diurnal swings in DO, including supersaturation of oxygen during when photosynthesis is occurring, and very low levels when oxygen is consumed during decomposition of the algal biomass after it dies and settles to the bottom.

Figure 5 provides a time series plot of measured DO concentrations in WBID 1536F of Six Mile Creek. The dataset includes several profile measurements taken at different depths on the same date at stations 21FLHILL147 and 21FLWQSPHIL591CA. There were 5 monitoring stations that included a total of 366 observations of which 99 (27 percent) fell below the water quality standard of 5 mg/l DO. The minimum value was 0.06 mg/l, the maximum was 14.3 mg/l and the average was 6.3 mg/l. Generally, the lowest DO concentrations were measured during the warmer summer and fall months, with the lowest DO concentrations measured at depth. A seasonal signature in DO concentrations is not unexpected, since water temperature has a significant influence on DO concentrations. Warmer water is not capable of dissolving as much oxygen as cooler water. DO saturation, which is calculated as the percentage of the measured DO level relative to the maximum (i.e. saturated) concentration expected at the sampled water temperature, can be one way to analyze DO patterns without the confounding influence of temperature. In WBID 1536F, saturation DO ranges from 2.7 percent to 179.6 percent, averaging 74.8 percent (Figure 6).

Even when depth profile data are averaged, so that each sample date is represented by only one value, the DO concentrations still range from 0.7 mg/l to 12 mg/l, and average 6.7 mg/l (Figure 7). This wide range of DO concentrations, including the wide range of saturation DO values, is indicative of a system where fluctuations are exacerbated by the photosynthesis, respiration, and decomposition of aquatic plants. Algal blooms have been observed in WBID 1536F (FDEP, 2003). The profile measurements taken from one monitoring location at increasing depths illustrate that the lower pool of Six Mile Creek is also highly stratified, with supersaturated concentrations at the surface, and very low DO conditions at depth.

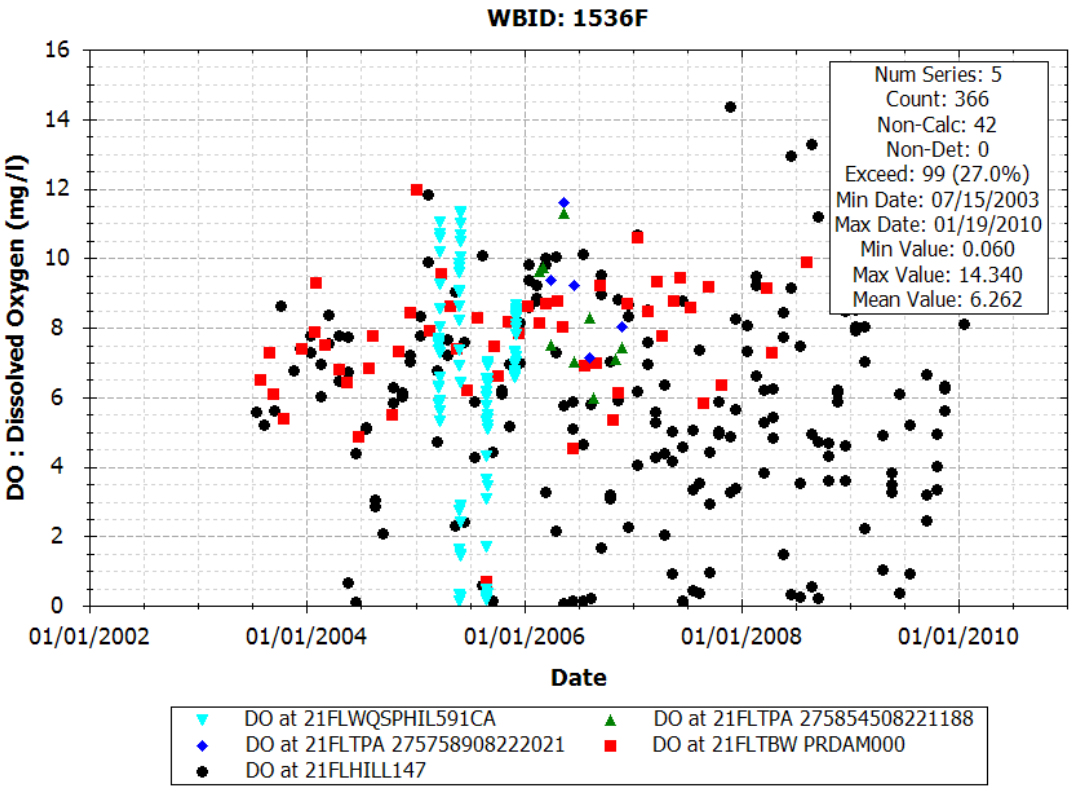

Figure 5. Measured DO in Six Mile Creek WBID 1536F.

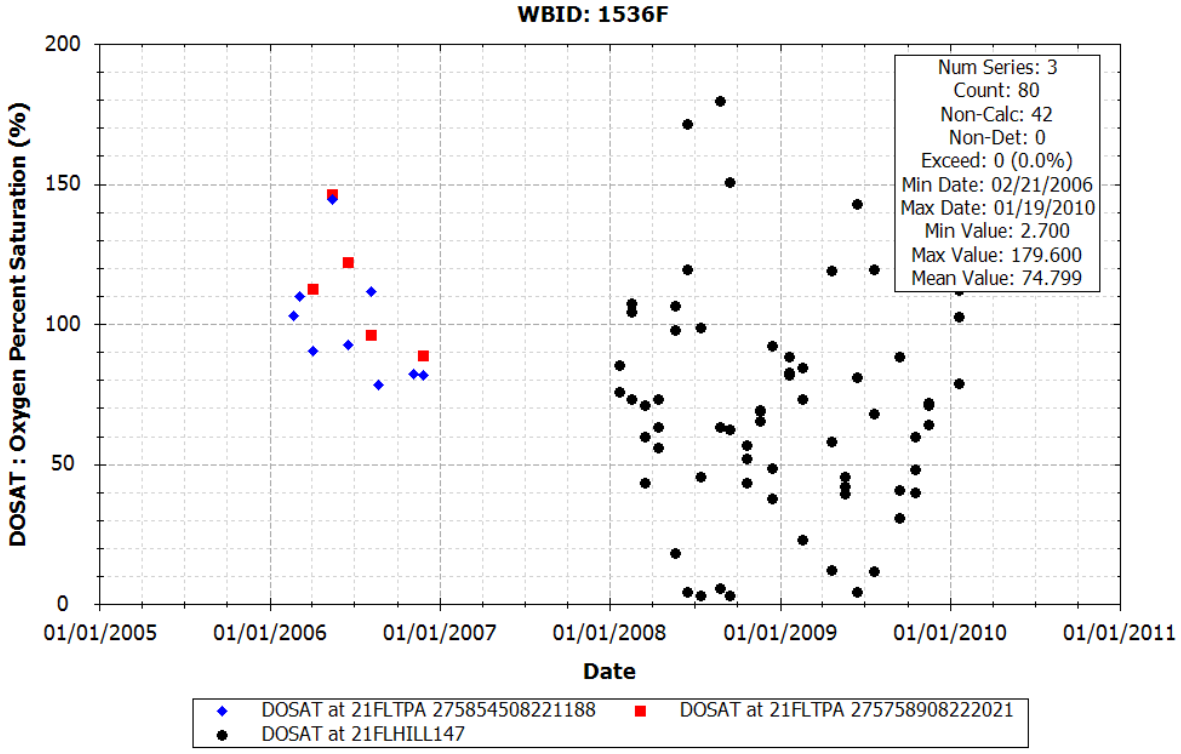

Figure 6. DOSAT measurements in Six Mile Creek WBID 1536F.

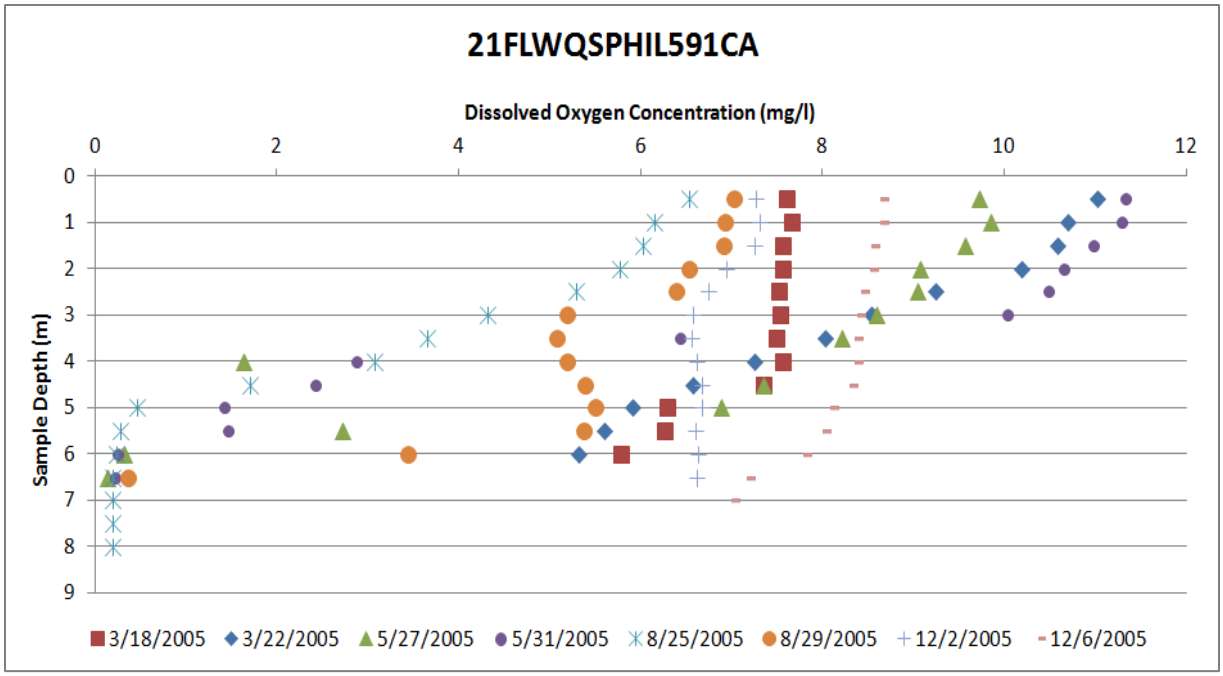

Figure 7. DO profile measurements taken at station 21FLWQSPHIL591CA (WBID 1536F).

Biochemical Oxygen Demand

BOD is a measure of the amount of oxygen used by bacteria as they stabilize organic matter. Figure 8 provides a time series plot for the measured BOD concentrations in the Six Mile Creek WBID 1536F. There were 3 monitoring stations used in the assessment that included a total of 66 observations. The minimum value was 0.9 mg/l, the maximum was 10.4 mg/l and the average was 3.1 mg/l. These BOD concentrations are high enough to contribute to suppression of DO concentrations in the lower pool of Six Mile Creek (WBID 1536F).

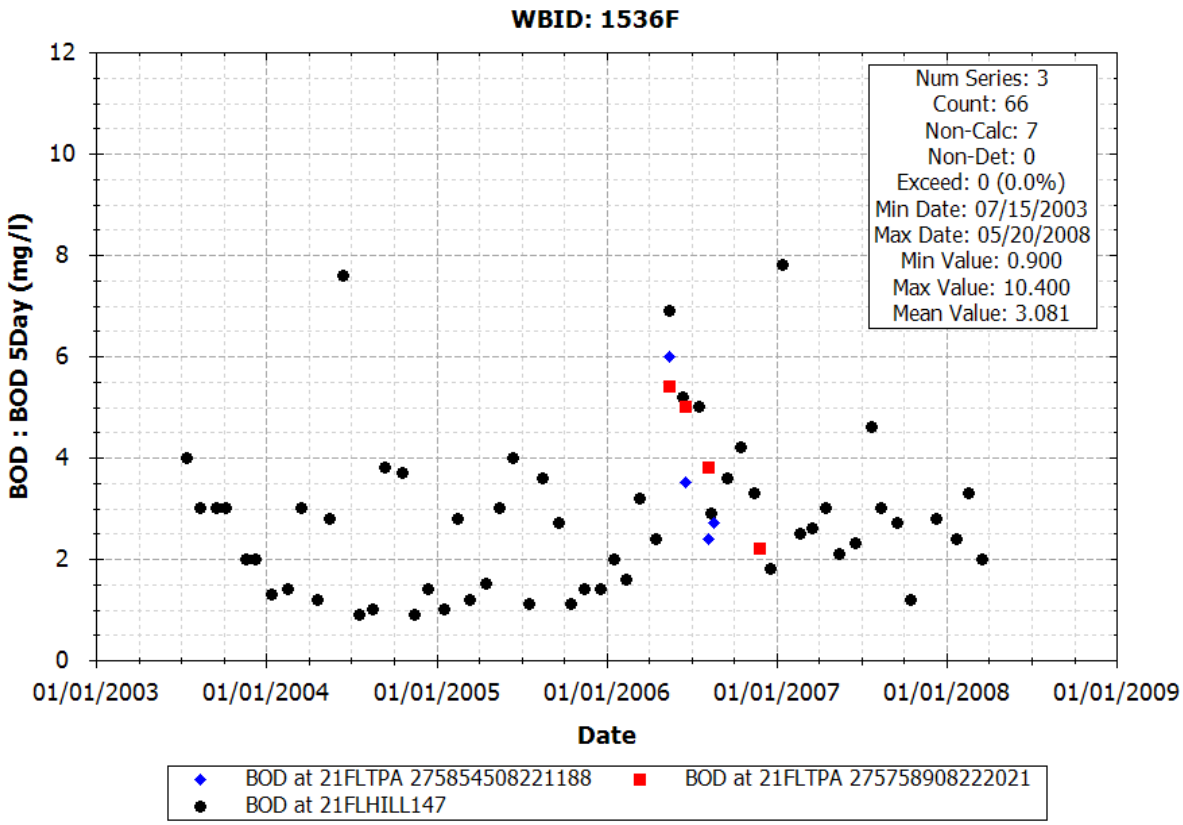

Figure 8. Measured BOD in Six Mile Creek WBID 1536F.

Nutrients

As discussed above, excessive nutrients in a waterbody can lead to overgrowth of algae and other aquatic plants such as phytoplankton, periphyton and macrophytes. This process can deplete oxygen in the water, adversely affecting aquatic life and potentially restricting recreational uses. For the nutrient assessment, monitoring data for total nitrogen, total phosphorus and chlorophyll-*a* are presented. The purpose of the nutrient assessment is to present the range, variability and average conditions for the WBID.

Total Nitrogen

Total nitrogen (TN) is comprised of nitrate (NO_3), nitrite (NO_2), organic nitrogen and ammonia nitrogen (NH_4). Figure 9 provides a time series plot for the measured TN concentrations in Six Mile Creek WBID 1536F. There were 5 monitoring stations used in the assessment that included a total of 114 observations. The minimum value was 0.27 mg/l, the maximum was 2.51 mg/l and the average was 0.83 mg/l. By comparing paired measurements of ammonia, nitrate, and organic nitrogen, it was determined that the majority of total nitrogen in Six Mile Creek is organic in nature. Although the fractions vary significantly, on average, only about 5 percent of total nitrogen is ammonia-nitrogen, while about 5 to 10 percent is nitrate-nitrogen.

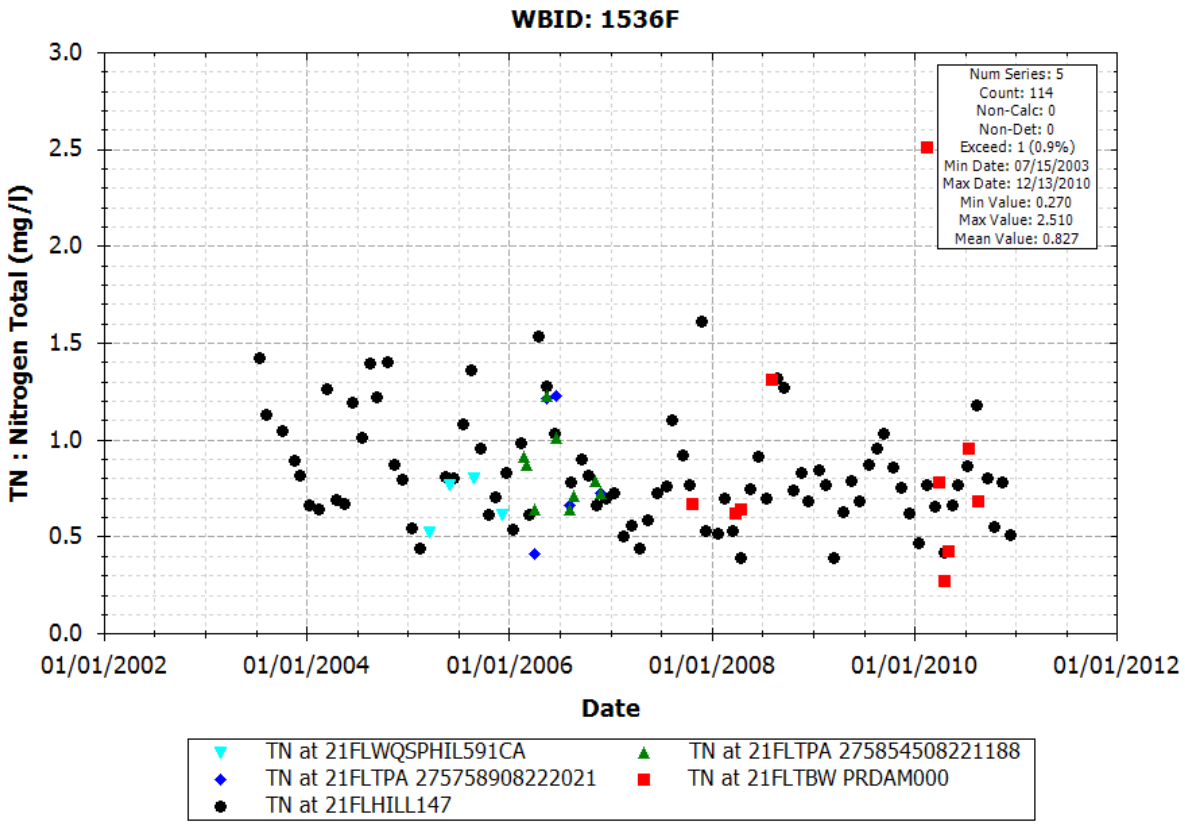

Figure 9. Measured Total Nitrogen in Six Mile Creek WBID 1536F.

Total Phosphorus

In natural waters, total phosphorus exists in either soluble or particulate forms. Dissolved phosphorus includes inorganic and organic forms, while particulate phosphorus is made up of living and dead plankton, and adsorbed, amorphous, and precipitated forms. Inorganic forms of phosphorus include orthophosphate and polyphosphates, though polyphosphates are unstable and convert to orthophosphate over time. Orthophosphate is both stable and reactive, making it the form most used by plants. Excessive phosphorus can lead to overgrowth of algae and aquatic plants, the decomposition of which uses up oxygen from the water. Figure 10 provides a time series plot for the measured total phosphorus concentrations in WBID 1536F of Six Mile Creek. There were 5 monitoring stations used in the assessment that included a total of 118 observations. The minimum value was 0.05 mg/l, the maximum was 0.68 mg/l and the average was 0.15 mg/l. A comparison of paired measurements of total phosphorus and dissolved orthophosphate showed that it is typical for more than half of the total phosphorus in Six Mile Creek to be comprised of orthophosphorus. Dissolved orthophosphorus is the form that is most readily available for uptake by aquatic plants.

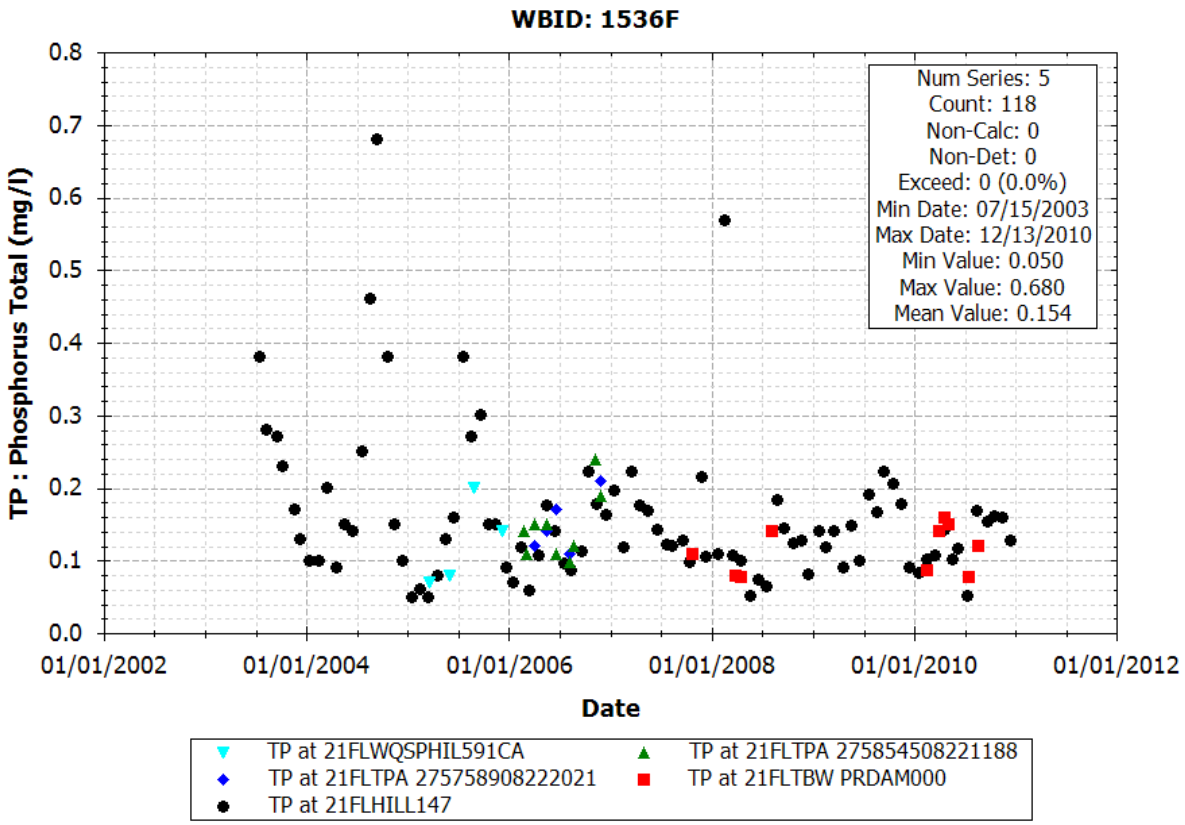

Figure 10. Measured Total Phosphorus in Six Mile Creek WBID 1536F.

Chlorophyll-a

Chlorophyll is the green pigment in plants that allows them to create energy from light. In a water sample, chlorophyll is indicative of the presence of algae, and chlorophyll-*a* is a measure of the active portion of total chlorophyll. Corrected chlorophyll refers to chlorophyll-*a* measurements that are corrected for the presence of pheophytin, a natural degradation product of chlorophyll that can interfere with analysis because it has an absorption peak in the same spectral region.

Figure 11 provides a time series plot for corrected chlorophyll-*a* concentrations in WBID 1536F of Six Mile Creek. There were 5 monitoring stations used in the assessment that included a total of 98 observations. The minimum value was 1.00 µg/l, the maximum was 198.8 µg/l and the average was 43.3 µg/l. The data reveal several instances of high algal concentrations in WBID 1536F, at different monitoring locations and points in time. This inference is supported by direct observations of algal blooms in Six Mile Creek (FDEP, 2003).

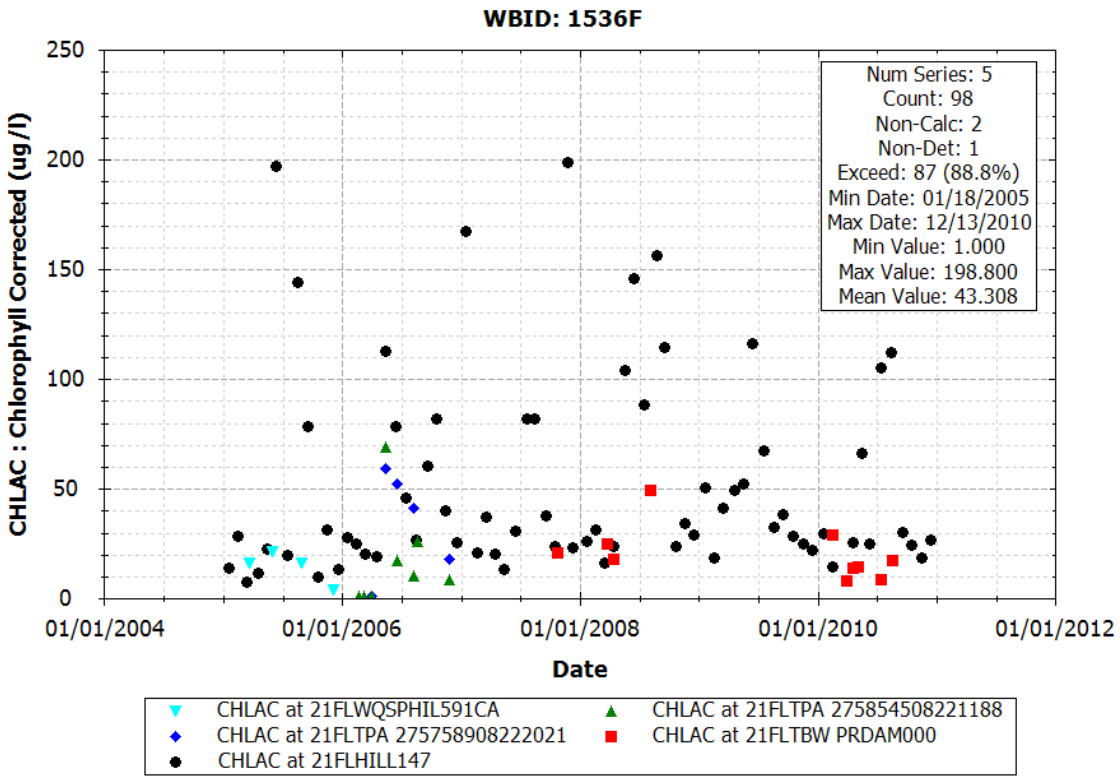

Figure 11. Measured Chlorophyll-*a* Concentrations in Six Mile Creek WBID 1536F.

5.1.2. WBID 1536B: Six Mile Creek

Table 4 identifies monitoring stations located in WBID 1536B and lists the time period over which water quality measurements were made at each location during the assessment period for IWR Version 44. Figure 12 illustrates where these monitoring stations are located. Stations 21FLWQSPHIL593CA, 21FLBRA1536B-C, 21FLHILL146 and 21FLBRA1536B-B are all located in the upper pool, upstream of structure S-159. Stations 21FLBRA1536B-A, 21FLGW 22071 and 21FLTPA275942408220599 are located in the middle pool of Six Mile Creek, toward the downstream end of WBID 1536B, upstream of structure S-162.

Table 4. Water Quality Monitoring Stations for WBID 1536B: Six Mile Creek.

Station	Station Name	First Date	Last Date	No. Obs
21FLWQSPHIL593CA	Upper Tampa Bypass Canal at Jefferson Rd (WBID 1536B)	04/25/2005	12/20/2005	118
21FLHILL146	Tampa Bypass Canal at south side of Fowler Ave. Bridge	07/23/2002	12/13/2010	1652
21FLBRA 1536B-C	1536B - Six Mile Creek - Bypass canal at Fowler	05/07/2008	06/05/2008	14
21FLBRA 1536B-B	1536B - Six Mile Creek -	08/08/2007	06/05/2008	31

Station	Station Name	First Date	Last Date	No. Obs
	Bridge on 301			
21FLBRA 1536B-A	1536B - Six Mile Creek - bridge on Garden Lane	06/15/2007	06/05/2008	93
21FLHILL604	Six Mile Creek @ Eureka Springs Rd	04/01/2009	11/30/2010	52
21FLGW 22071	SW1-SS-2008 SIX MILE CREEK	09/29/2004	09/29/2004	12
21FLTPA275942408220599	TP 426 - Six Mile Creek	02/06/2006	12/05/2006	361

NOTES: No. Obs.= Number of observations (various parameters) in IWR 44 current assessment period.

Figure 12. Location of Monitoring Stations in WBID 1536B of Six Mile Creek.

Dissolved Oxygen

The natural and anthropogenic factors that may affect DO concentrations in a waterbody are discussed in the preceding section (5.1.1). Figure 13 provides a time series plot of measured DO concentrations in WBID 1536B of Six Mile Creek. The dataset includes several profile measurements taken at different depths on the same date at stations 21FLHILL146 and 21FLWQSPHIL593CA. DO measurements in WBID 1536B occurred at 7 monitoring stations and included a total of 303 observations of which 113 (37 percent) fell below the water quality standard of 5 mg/l DO. The minimum value was 0.06 mg/l, the maximum was 14.1 mg/l and the average was 5.7 mg/l. This range is very similar to the range observed downstream, in WBID 1536F, and the average DO in WBID 1536B is similar but slightly lower that the average calculated for WBID 1536F. The lowest DO concentrations in WBID 1536B were also measured during the warmer summer and fall months, with the lowest DO concentrations measured at depth. Saturation DO ranges from 1.8 percent to 181.5 percent, averaging 71.9 percent (Figure 14). Profile measurements illustrate that the upper pool of Six Mile Creek is also highly stratified in warmer months, with high DO concentrations at the surface, and very low DO conditions at depth (Figure 15). The wide range of DO concentrations, including the wide range of saturation DO values, indicates that DO fluctuations are likely exacerbated by photosynthesis, respiration, and decomposition of aquatic plants within WBID 1536B.

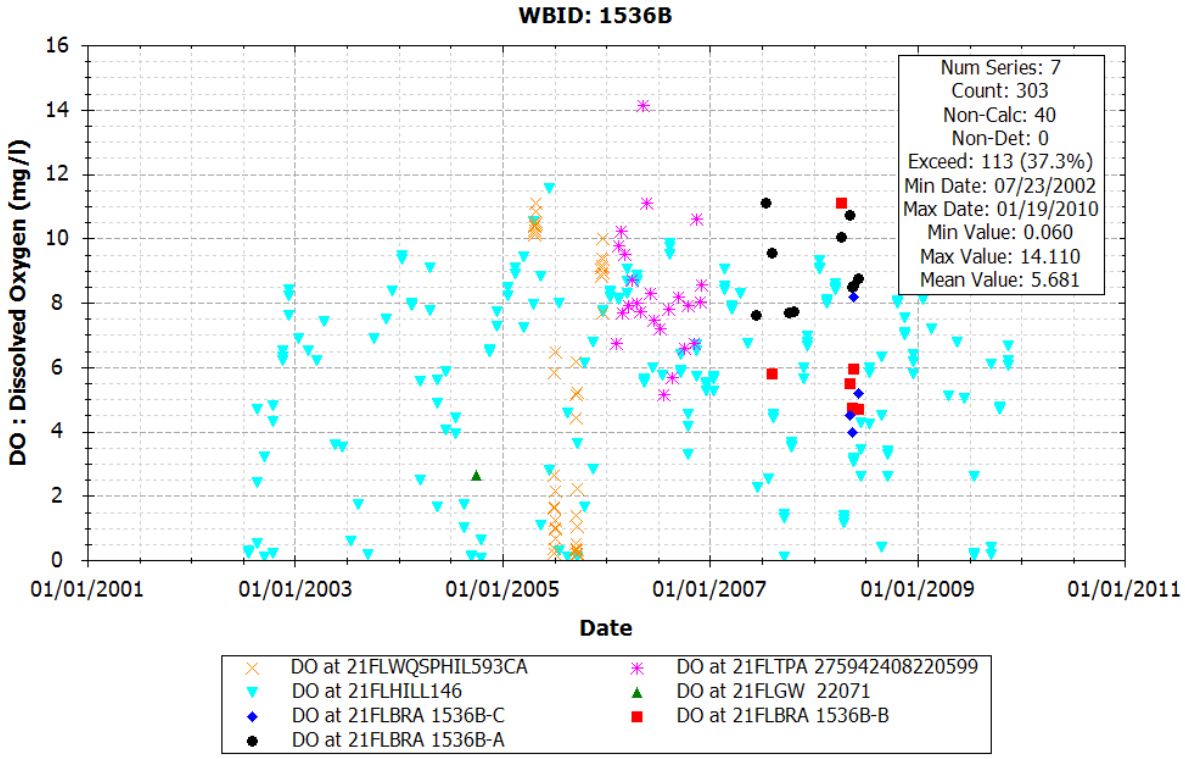

Figure 13. Measured DO in Six Mile Creek WBID 1536B.

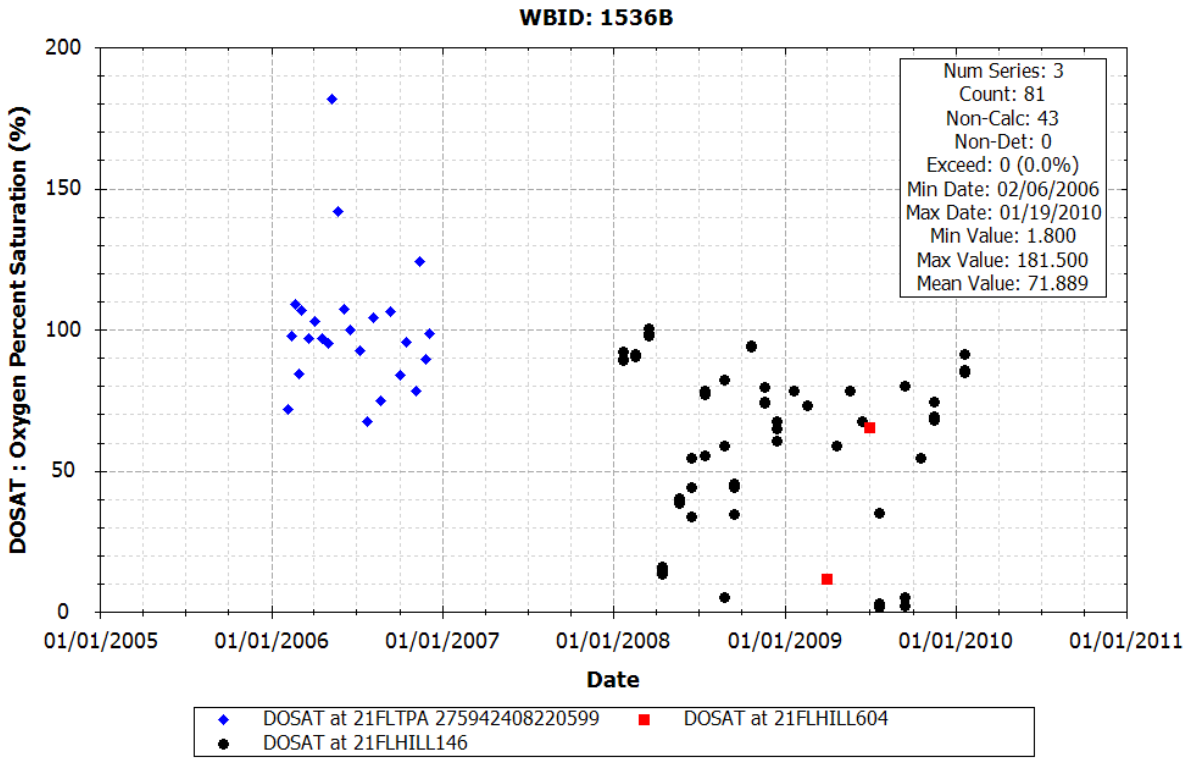

Figure 14. DOSAT measurements in Six Mile Creek WBID 1536B.

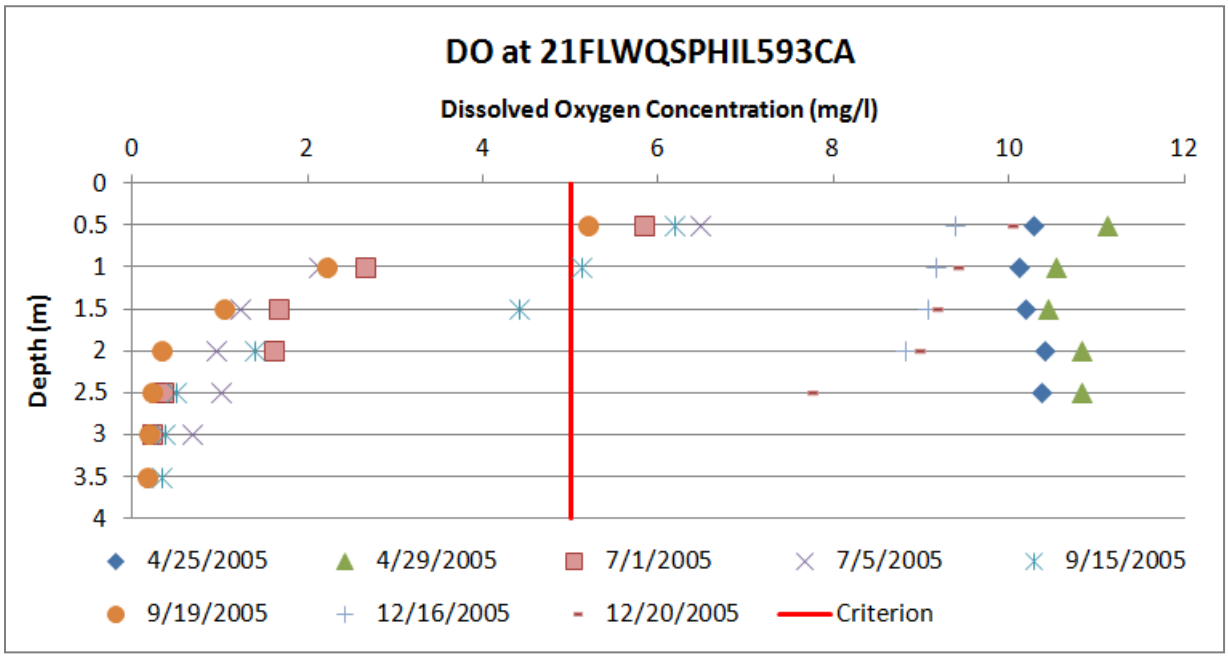

Figure 15. DO profile measurements taken at station 21FLWQSPHIL593CA (WBID 1536B).

Biochemical Oxygen Demand

Figure 16 provides a time series plot for the measured BOD concentrations in the upper and middle pools of Six Mile Creek (WBID 1536B). A total of 94 observations were made at 5 monitoring stations during the time period evaluated. The minimum BOD value was 0.4 mg/l, the maximum was 10.7 mg/l and the average was 2.7 mg/l. These BOD concentrations are similar to those in WBID 1536F; several measurements are high enough to conclude that BOD in WBID 1536B has the potential to contribute to suppression of DO.

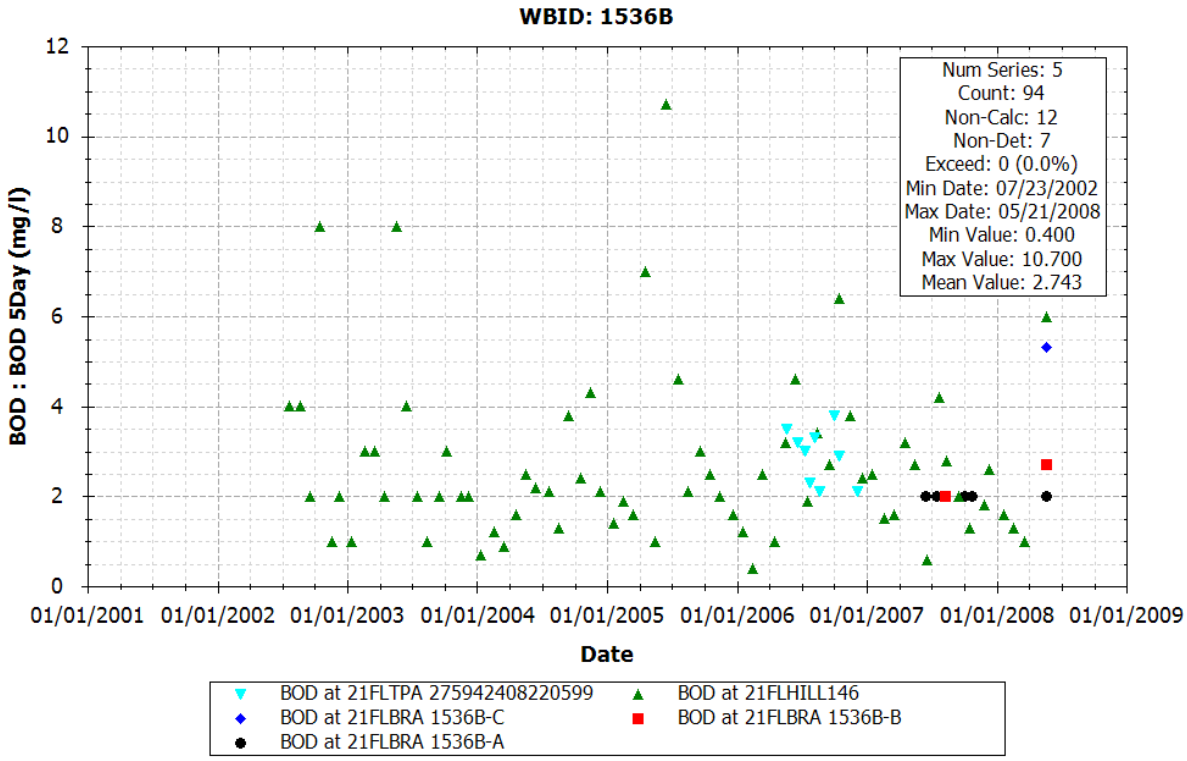

Figure 16. Measured BOD in Six Mile Creek WBID 1536B.

Nutrients

Nutrient and chlorophyll data for WBID 1536B were analyzed to determine the range, variability and current average conditions of the waterbody.

Total Nitrogen

Figure 17 shows a time series plot for the measured TN concentrations in Six Mile Creek WBID 1536B. There were 139 observations made at 6 monitoring stations. The minimum value was 0.27 mg/l, the maximum was 3.0 mg/l and the average was 0.89 mg/l. This range of concentrations, and the average, are comparable to those observed in WBID 1536F downstream.

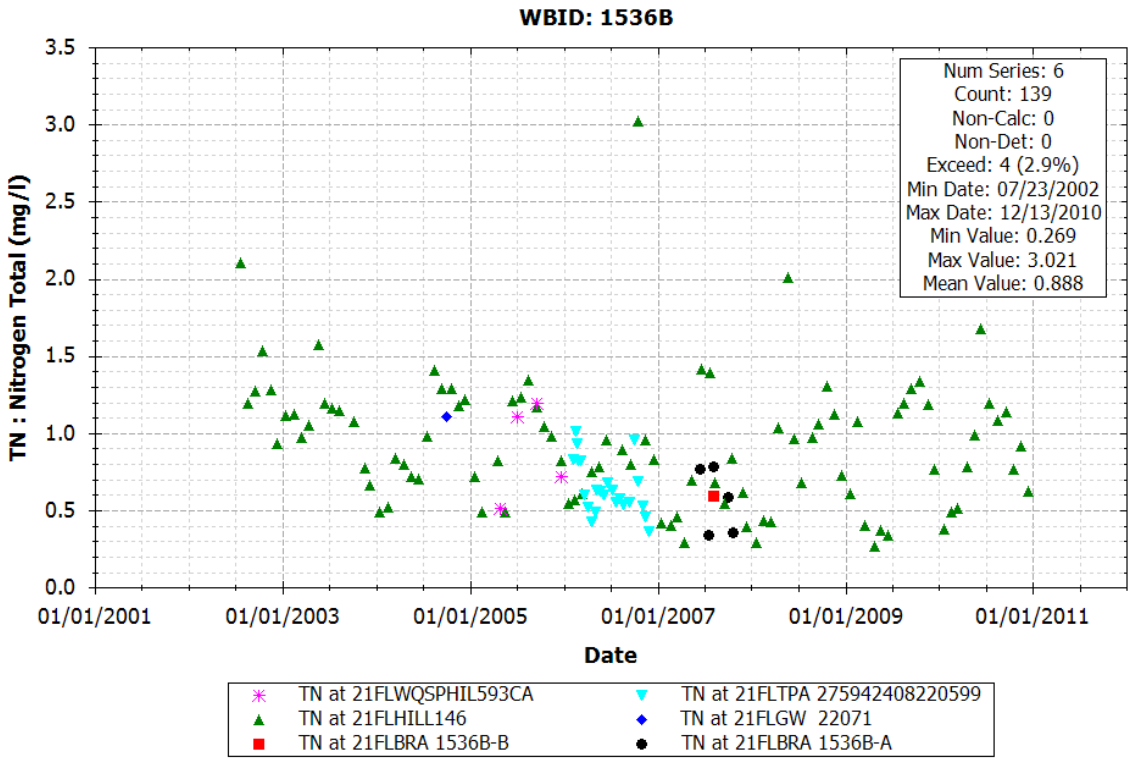

Figure 17. Measured Total Nitrogen in Six Mile Creek WBID 1536B.

Total Phosphorus

Figure 18 is a time series plot of measured total phosphorus concentrations in WBID 1536B of Six Mile Creek. There were 138 observations made at 6 monitoring stations. The minimum value was 0.02 mg/l, the maximum was 1.07 mg/l and the average was 0.21 mg/l. These minimum, maximum and average phosphorus concentrations are only slightly higher than those calculated for WBID 1536F.

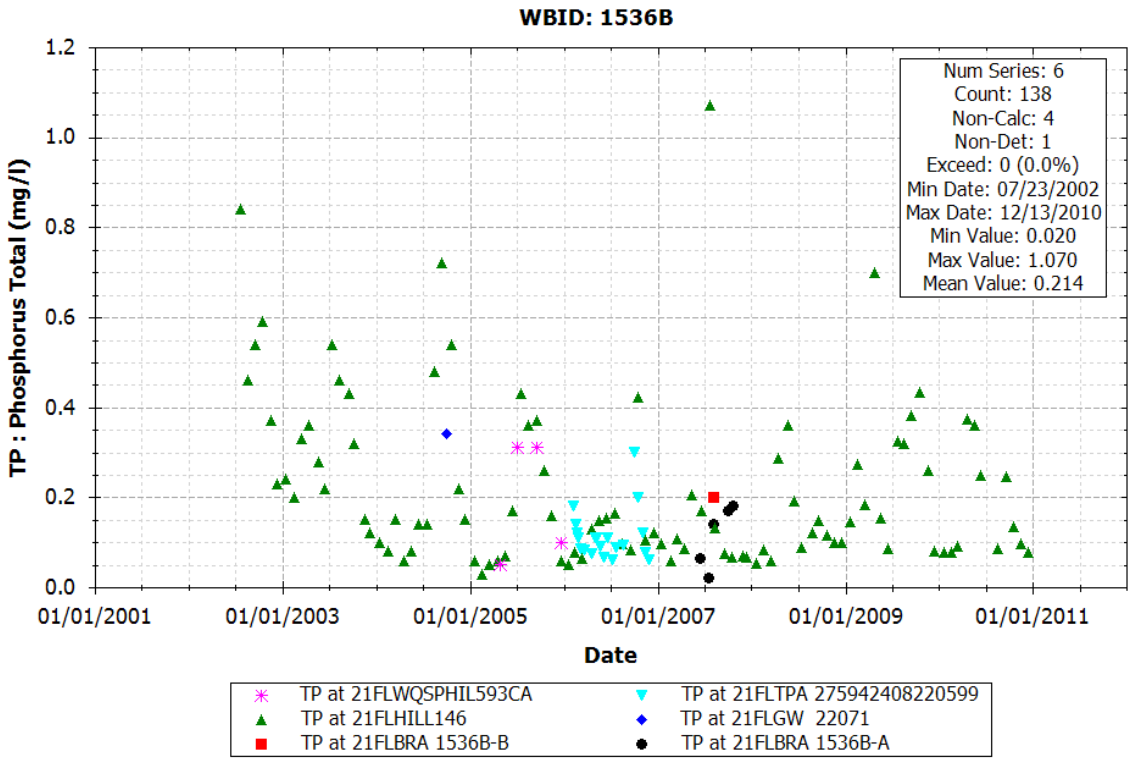

Figure 18. Measured Total Phosphorus in Six Mile Creek WBID 1536B.

Chlorophyll-a

Figure 19 provides a time series plot for corrected chlorophyll-*a* concentrations in WBID 1536B. There were 6 monitoring stations used in the assessment that included a total of 101 observations. The minimum value was 1.00 µg/l, the maximum was 104.8 µg/l and the average was 23.8 µg/l. Although the range and average of chlorophyll concentrations in WBID 1536B is lower than those in WBID 1536F, the data still reveal several instances of elevated algal concentrations at different monitoring locations and points in time.

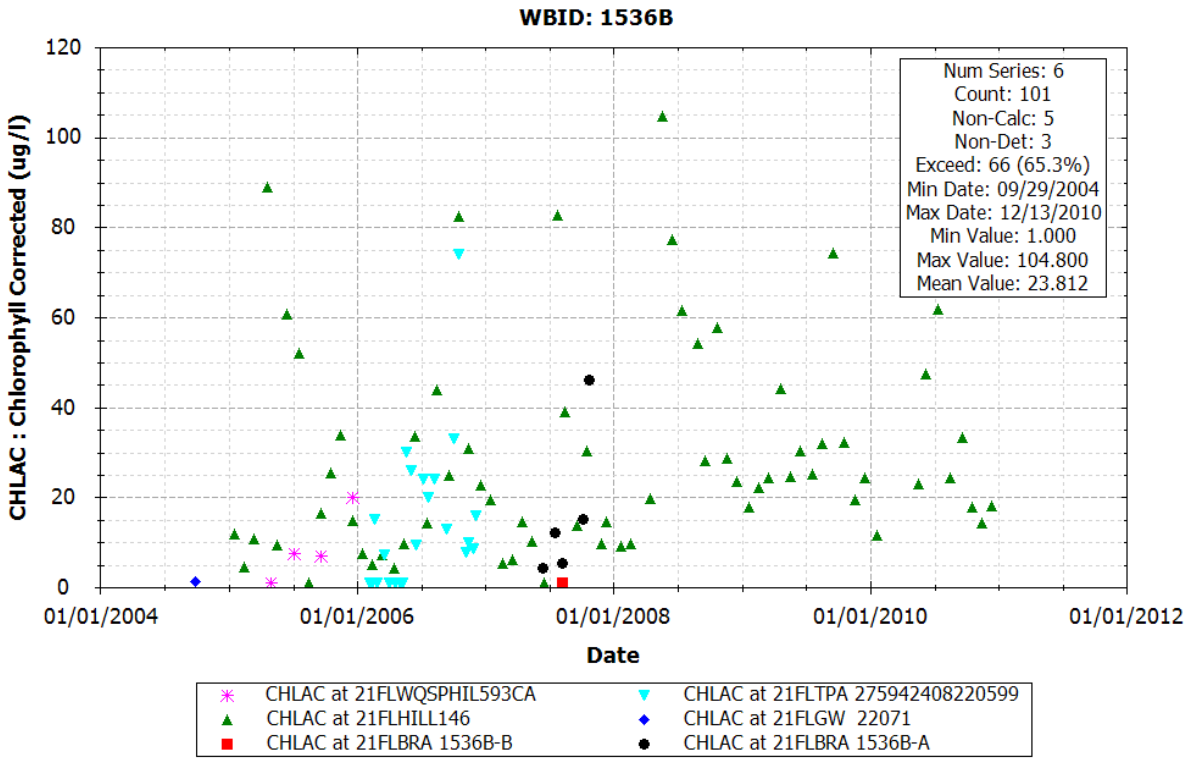

Figure 19. Measured Chlorophyll-*a* Concentrations in Six Mile Creek WBID 1536B.

Stream Flow

Stream flow is an important factor affecting water quality, especially insofar as it determines the available loading capacity for pollutants such as nutrients and bacteria. Flow conditions also influence DO concentrations more directly. Typically, higher flows are associated with higher DO levels, since the increased flow leads to greater turbulence and aeration. As described above, the flow of Six Mile Creek is almost entirely regulated by a series of structures that divide it into upper, middle and lower pools (Figure 1). Water may be pumped from, or added to, Six Mile Creek based on water supply needs and the need for flow diversion to prevent flooding in nearby populated areas. These structures are jointly controlled by Tampa Bay Water and the Southwest Florida Water Management District. The data, which reflect changes to the flow management strategy as much as changes in climatic conditions, show that the amount of water released from the lower pool of Six Mile Creek through S-160 has been highly variable, and that less water has been released in recent years (Figure 20). The control structures mean that Six Mile Creek often behaves more like a ponded waterbody than a free-flowing stream.

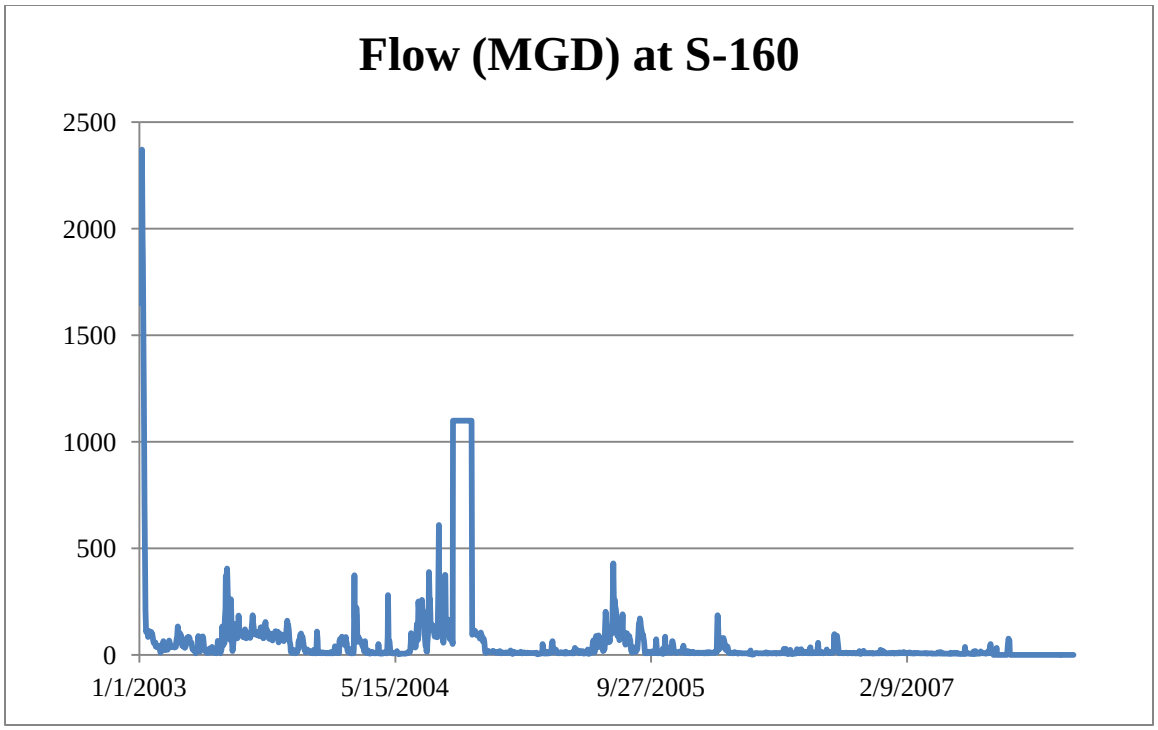

Figure 20. Daily discharge at S-160 on Six Mile Creek.

5.2. Summary of Data Assessments

DO in the freshwater portion of Six Mile Creek has a wide range in concentration- as well as percent saturation- and is frequently below the Class III freshwater criterion of 5 mg/l, even at different times of the year. The chlorophyll-*a* data show, and observations confirm, that there have been several instances of high algal concentrations at various monitoring locations and points in time. BOD levels are high enough to contribute to suppression of DO levels. The nutrient data show that the majority of TN is organic in nature, while the majority of phosphorus is in the readily available form of orthophosphate. Common sources of organic nitrogen are plant matter and animal wastes, including septic systems and sewer lines. Based on this information, and the presence of potential sources of relevant pollutants, EPA is proposing TMDLs for nutrients, BOD and DO for Six Mile Creek (WBIDs 1536F and 1536B).

6. Source and Load Assessment

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of pollutants in the watershed and the amount of loading contributed by each of these sources. Sources are broadly classified as either point or nonpoint sources. Nutrients can enter surface waters from both point and nonpoint sources.

6.1. Point Sources

A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges of industrial wastewater and treated sanitary wastewater must be authorized by National Pollutant Discharge Elimination System (NPDES) permits. NPDES permitted discharges include continuous discharges such as wastewater treatment facilities as well as some stormwater driven sources such as municipal separate stormwater sewer systems (MS4s), certain industrial facilities, and construction sites over one acre.

6.1.1. Wastewater/Industrial Permitted Facilities

A TMDL wasteload allocation (WLA) is given to wastewater and industrial NPDES permitted facilities discharging to surface waters within an impaired watershed. There are no NPDES permitted facilities with direct, surface water discharges draining to WBID 1536B or WBID 1536F of Six Mile Creek.

6.1.2. Stormwater Permitted Facilities/MS4s

The 1987 amendments to the Clean Water Act designated certain stormwater discharges as point sources requiring NPDES stormwater permits. The regulated activities involve Municipal Separate Storm Sewer Systems (MS4s), construction sites over one acre, and specific industrial operations. Although these types of stormwater discharges are now considered point sources with respect to permitting and TMDLs, they behave similarly to nonpoint sources in that they are driven by rainfall-runoff processes leading to the intermittent discharge of pollutants from land use activities in response to storms.

According to 40 CFR 122.26(b)(8), an MS4 is "a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

(i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law)...including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act that discharges into waters of the United States.

(ii) Designed or used for collecting or conveying storm water;

(iii) Which is not a combined sewer; and

(iv) Which is not part of a Publicly Owned Treatment Works."

MS4s may discharge nutrients and other pollutants to waterbodies in response to storm events. In 1990, USEPA developed rules establishing Phase I of the NPDES stormwater

program, designed to prevent harmful pollutants washed into MS4s by stormwater runoff, or dumped directly into them, from being delivered to local waterbodies. Phase I of the program required operators of "medium" and "large" MS4s (generally serving populations of 100,000 or more) to implement a stormwater management program as a means of controlling polluted discharges. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality related issues including roadway runoff management, municipal owned operations, and hazardous waste treatment, etc. Because the master drainage systems of most local governments in Florida are interconnected, USEPA implemented Phase 1 of the MS4 permitting program on a countywide basis, which brings in all cities, Chapter 298 urban water control districts, and the Florida Department of Transportation throughout the 15 counties meeting the population criteria.

Phase II of the rule extends coverage of the NPDES stormwater program to certain "small" MS4s. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the NPDES stormwater program. Only a select subset of small MS4s, referred to as "regulated small MS4s", requires an NPDES stormwater permit. Regulated small MS4s are defined as all small MS4s located in "urbanized areas" as defined by the Bureau of the Census, and those small MS4s located outside of "urbanized areas" that are designated by NPDES permitting authorities.

In October 2000, USEPA authorized FDEP to implement the NPDES stormwater program in all areas of Florida except Indian tribal lands. FDEP's authority to administer the NPDES program is set forth in Section 403.0885, Florida Statutes (FS). The three major components of NPDES stormwater regulations are:

- MS4 permits that are issued to entities that own and operate master stormwater systems, primarily local governments. Permittees are required to implement comprehensive stormwater management programs designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable.

- Stormwater associated with industrial activities, which is regulated primarily by a multisector general permit that covers various types of industrial facilities. Regulated industrial facilities must obtain NPDES stormwater permit coverage and implement appropriate pollution prevention techniques to reduce contamination of stormwater.

- Construction activity general permits for projects that ultimately disturb one or more acres of land and which require the implementation of stormwater pollution prevention plans to provide for erosion and sediment control during construction.

Hillsborough County, District 7 of the Florida Department of Transportation and other co-permittees are covered under Phase I MS4 permit FLS000006, which encompasses the majority of the watershed draining to the impaired WBIDs. Small portions of the individual

Phase I MS4 permits held by the City of Tampa (FLS000008) and the City of Temple Terrace (FLS000009) may also encroach upon the watershed. Stormwater discharges conveyed through the storm sewer systems covered by these permits, and discharged within the Six Mile Creek watershed, are subject to the WLA of the TMDL.

6.2. Nonpoint Sources

Nonpoint sources of pollution are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For nutrients, these sources include runoff from agricultural fields and golf courses, as well as lawns, septic tanks, and residential developments outside of MS4 areas. Nonpoint source pollution generally involves a buildup of pollutants on the land surface that wash off during rain events and as such, represent contributions from diffuse sources, rather than from a defined outlet. Potential nonpoint sources are commonly identified, and their loads estimated, based on land cover data. Most methods calculate nonpoint source loadings as the product of the water quality concentration and runoff water volume associated with certain land use practices. The mean concentration of pollutants in the runoff from a storm event is known as the Event Mean Concentration, or EMC.

6.2.1. Urban Areas

Urban areas include land uses such as residential, industrial, extractive and commercial. Land uses in this category typically have somewhat high total nitrogen event mean concentrations and average total phosphorus event mean concentrations. Nutrient loading from MS4 and non-MS4 urban areas is attributable to multiple sources including stormwater runoff, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals.

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as outlined in Chapter 403 FS, was established as a technology-based program that relies upon the implementation of Best Management Practices (BMPs) that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, FAC.

Florida's stormwater program is unique in having a performance standard for older stormwater systems that were built before the implementation of the Stormwater Rule in 1982. This rule states: "the pollutant loading from older stormwater management systems shall be reduced as needed to restore or maintain the beneficial uses of water." [FAC 62-40-.432(2)(c)]

Nonstructural and structural BMPs are an integral part of the State's stormwater programs. Nonstructural BMPs, often referred to as "source controls", are those that can be used to prevent the generation of nonpoint source pollutants or to limit their transport off-site. Typical nonstructural BMPs include public education, land use management, preservation of wetlands and floodplains, and minimization of impervious surfaces. Technology-based

structural BMPs are used to mitigate the increased stormwater peak discharge rate, volume, and pollutant loadings that accompany urbanization.

Urban, residential, industrial and commercial developments are expected to be the most significant source of nutrients and oxygen-demanding substances in the Six Mile Creek watershed. Land uses in this category comprise about 65 percent of the watershed area. Of the 11,704 acres of the watershed in this category, over half (54 percent) is classified as a residential use, and another 27 percent is classified as commercial or industrial.

Onsite Sewage Treatment and Disposal Systems (Septic Tanks)

As stated above, leaking septic tanks or onsite sewage treatment and disposal systems (OSTDs) can contribute to nutrient loading from residential areas. Water from OSTDs is typically released to the ground through on-site, subsurface drain fields or boreholes that allow the water from the tank to percolate (usually into the surficial aquifers) and either transpire to the atmosphere through surface vegetation or add to the flow of shallow ground water. When properly sited, designed, constructed, maintained, and operated, OSTDs are a safe means of disposing of domestic waste. The effluent from a well-functioning OSTD receives natural biological treatment in the soil and is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, OSTDs can be a source of nutrients, pathogens, and other pollutants to both ground water and surface water.

Hillsborough County has an ongoing program to identify the locations of septic tanks based on records obtained from the Florida Department of Health and sewer billing records (USEPA, 2009). As of 2009, the number of septic tanks in this watershed area was estimated to be 1,815. The location of these septic tanks is shown in (Figure 21).

Given the prevalence of residential development in the watershed, and the high number of septic tanks in Hillsborough County, it is possible that leaking septic systems are a relevant source of organic and nutrient loading in the Six Mile Creek watershed.

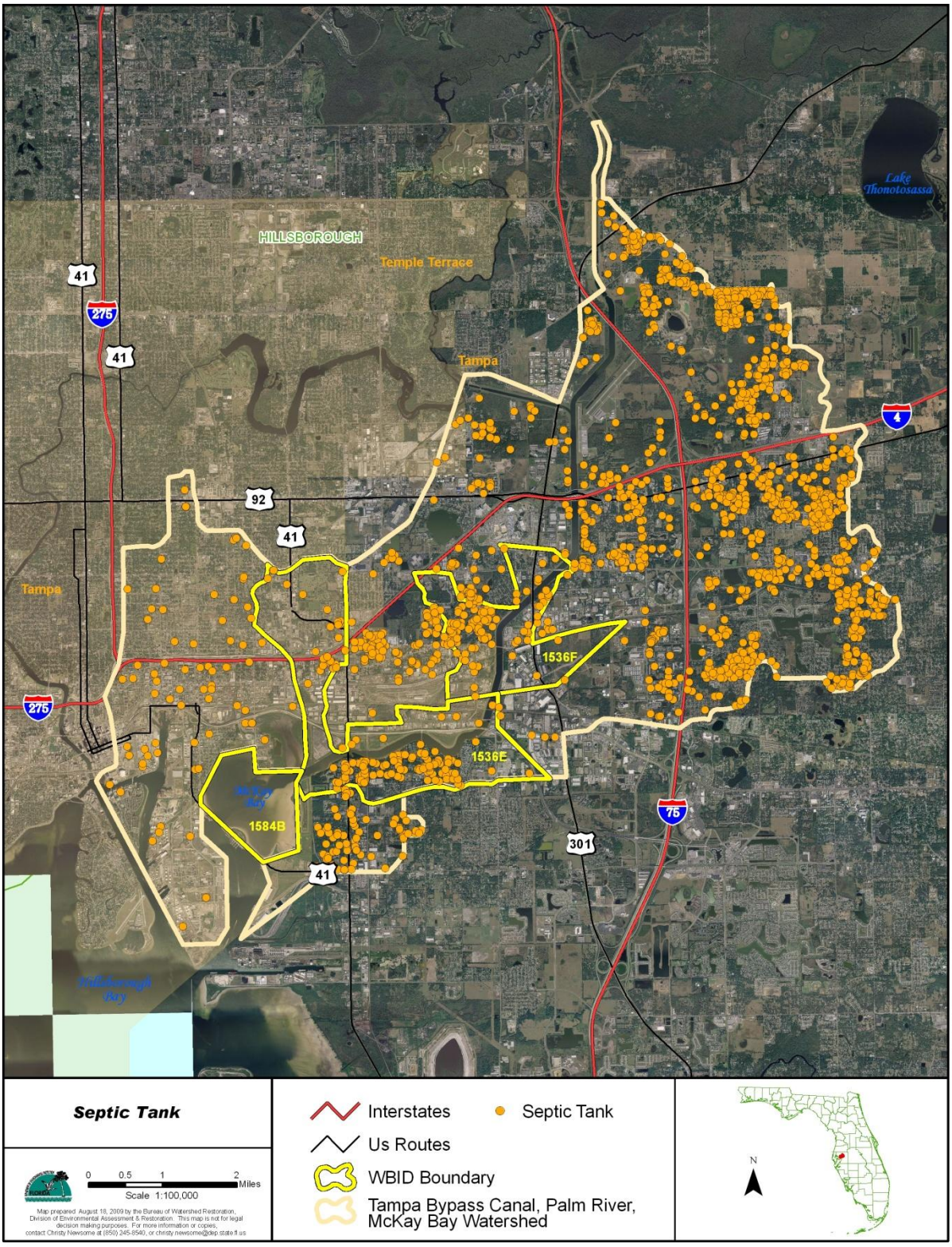

Figure 21. Location of septic tanks in the Tampa Bypass Canal, Palm River and McKay Bay Watershed.

6.2.2. Agriculture

Agricultural lands include improved and unimproved pasture, row and field crops, tree crops, nurseries, and specialty farms. Agricultural activities, including runoff of fertilizers or animal wastes from pasture and cropland and direct animal access to streams, can generate nutrient loading. The highest total nitrogen and total phosphorus event mean concentrations are associated with agricultural land uses. Land use data and aerial coverage show that agriculture has some presence in the upper reaches of the watershed, comprising about seven percent of the landuse (Figure 3 and Table 1).

6.2.3. Rangeland

Rangeland includes herbaceous, scrub, disturbed scrub and coastal scrub areas. Event mean concentrations for rangeland are about average for total nitrogen and low for total phosphorus. A minimal amount of the area in the Six Mile Creek watershed is classified as rangeland.

6.2.4. Upland Forests

Upland forests include flatwoods, oak, various types of hardwoods, conifers and tree plantations. Event mean concentrations for upland forests are low for both total nitrogen and total phosphorus. Upland Forests cover only about five percent of the area in the Six Mile Creek watershed.

6.2.5. Water and Wetlands

Water and wetlands have very low event mean concentrations and comprise about 5 and 10 percent of the land use in the Six Mile Creek watershed, respectively.

6.2.6. Barren Land

Barren land includes beaches, borrow pits, disturbed lands and fill areas. Event mean concentrations for barren lands tend to be higher in total nitrogen. None of the Six Mile Creek watershed is classified as barren.

6.2.7. Transportation, Communications and Utilities

Transportation uses include airports, roads and railroads. Event mean concentrations for these types of uses are in the mid-range for total nitrogen and total phosphorus. The Tampa Executive Airport, Interstate 75, and Interstate 4, as well as other roads contribute to the approximately eight percent of the watershed classified in this category.

7. Analytical Approach

In the development of a TMDL there needs to be a method for relating current pollutant loadings to the observed water quality problem. Various methods that rely on physical and biological relationships can be used to establish the cause and effect relationship. These approaches could be: statistical (e.g. using a regression between cause and effect variables), empirical (i.e. based on observations not necessarily from the waterbody in question) or mechanistic (i.e. physically and/or stochastically-based).

Current nutrient levels in Six Mile Creek were compared to various potential instream targets, and also to the loads deemed necessary to protect against adverse water quality impacts downstream. The final TMDL allocations were set to ensure that pollutant loadings from the Six Mile Creek watershed would not cause or contribute to nutrient or dissolved oxygen impairment in the receiving waters of the tidal Palm River, McKay Bay and Hillsborough Bay system. Watershed loads developed for the Nitrogen Management Consortium Reasonable Assurance Plan were used to predict both current and natural pollutant loadings of total nitrogen, total phosphorus, BOD, and dissolved oxygen emanating from the Six Mile Creek watershed, which were input into hydrodynamic and water quality models in order to evaluate the impacts of these pollutant loading scenarios. The models were calibrated to current conditions and then used to predict improvements in water quality as function of reductions in loadings. The time period considered in the development of this TMDL is January 1, 2003 to December 31, 2007, to coincide with the simulation period used for the estuarine models that simulated the downstream receiving waters.

7.1. TMDL Targets

Various previous efforts have interpreted Florida's narrative nutrient criteria for all or part of the watershed draining to McKay Bay, including the Six Mile Creek/Tampa Bypass Canal subwatershed. Nutrient levels in Six Mile Creek were evaluated to determine whether they were meeting these potential instream targets.

7.1.1. Florida's Adopted Numeric Nutrient Criteria for Rivers and Streams

Florida's recently adopted nutrient criteria numerically interpret the narrative water quality criteria in paragraph 62-302.530(48)(b), F.A.C. (See section 62-302.531(2).) The Florida rule clarifies that the narrative water quality criteria for nutrients in paragraph 62-302.530(47)(a), F.A.C., continue to apply to all Class III waters. (See section 62-302.531(1).)

Florida's recently adopted rule applies to streams, including Six Mile Creek. For streams that do not have site-specific criteria, Florida's rule states that biological information will be considered together with nutrient thresholds to determine whether a waterbody is attaining the standards described in 62-302.531(2)(c), F.A.C. The rule provides that the nutrient criteria are attained in a stream segment where information on chlorophyll-*a* levels, algal mats or blooms, nuisance macrophyte growth, and changes in algal species composition indicates that there are no imbalances in flora and either the average score of at least two temporally independent Stream Condition Index (SCI) tests performed at representative locations and

times is 40 or higher, with neither of the two most recent SCI scores less than 35, or the nutrient thresholds set forth in Table 2 are achieved. (See section 62-302.531(2)(c).) The SCI test is a primary indicator for ecosystem health and can be used to identify impairment with respect to a reference condition. Seven benthic (bottom-dwelling) macroinvertebrate metrics are used which measure diversity, composition, and functional feeding group representation, and provide information on the pollution tolerance of the species present. The information from these metrics is combined to generate a Stream Condition Index (SCI) for Florida.

In its analysis of nutrient levels in flowing waters, FDEP divided the state of Florida into Nutrient Watershed Regions (NWRs) so that the rivers and streams in them would share similar characteristics such as underlying geologic materials, nitrogen and phosphorus concentrations, and nitrogen to phosphorus ratios. The adopted rule contains six separate NWRs: Panhandle West, Panhandle East, North Central, West Central, Peninsular, and South Florida. Additional information about the NWRs and details about the development of the criteria may be found in the technical support document for the rule (FDEP, 2012).

Six Mile Creek is located within the West Central NWR. The targets for the West Central NWR are annual geometric mean concentrations not to exceed 1.65 mg/l total nitrogen or 0.49 mg/l total phosphorus more than once in a three-year period (Section 62-302.200 (25)(e), F.A.C.).

7.1.2. Tampa Bypass Canal Tributary TMDL

FDEP developed, and EPA proposed and established, a TMDL to address dissolved oxygen and nutrient impairment for a major tributary of Six Mile Creek (USEPA, 2012a). This stream, known as the Tampa Bypass Canal Tributary, enters the middle pool of Six Mile Creek and is designated WBID 1536C. The TMDL utilized a reference waterbody approach to derive target nutrient concentrations using data from waters within the Tampa Bay watershed (Bone Valley Ecoregion) that were similar to the impaired waterbody in terms of hydrologic conditions and drainage area, but that were not impaired for either DO or nutrients. The TMDL targeted maintenance of total nitrogen and total phosphorus at or below annual averages of 1.16 mg/l and 0.473 mg/l, respectively. Additional information about the derivation of these target concentrations may be found in the TMDL report.

7.1.3. McKay Bay/Hillsborough Bay TMDL

EPA recently proposed a TMDL for dissolved oxygen and nutrients in McKay Bay (WBID 1584B), Palm River (WBID 1536E) and Ybor City Drain (1584A; USEPA, 2012b). As explained earlier in this report, Six Mile Creek becomes the tidal Palm River downstream of Structure 160, which drains into McKay Bay, the East Bay, and on into Hillsborough Bay (see Figure 1). Based on previous studies, the TMDL proposed annual geometric mean targets of 1.01 mg/l total nitrogen, and 0.45 mg/l total phosphorus, to protect McKay, East and Hillsborough Bays. Since the impaired waterbodies were already meeting these annual geometric mean targets, the final TMDL endpoint was based on meeting applicable DO standards in the estuaries. The analysis indicated that the 5.0 mg/l daily average DO standard could not be met, so the TMDL allocations were set to natural condition TN and TP loadings.

7.1.4. Comparison to Potential Numeric Targets and Selection of Final Targets

Total nitrogen and total phosphorus data were obtained from Version 44 of FDEP's IWR database and used to calculate annual geometric means for Six Mile Creek WBIDs 1536F and 1536B. The calculated means were then compared to the potential targets discussed above (Table 5). As can be seen, the nitrogen concentrations in Six Mile Creek met each of these targets for all years, with the exception of 2003, when the annual geometric mean of total nitrogen was slightly higher than the lowest target. The total phosphorus concentrations in Six Mile Creek were well below all of the targets for every year.

Table 5. Comparison of Six Mile Creek to Numeric Targets.

	Nitrogen (mg/l)					Phosphorus (mg/l)				
	Six Mile Creek		Potential Targets			Six Mile Creek		Potential Targets		
Year	WBID 1536F	WBID 1536B	W. C. NWR	WBID 1536C	McKay Bay	WBID 1536F	WBID 1536B	W. C. NWR	WBID 1536C	McKay Bay
2003	1.02	1.05	1.65	1.16	1.01	0.23	0.28	0.49	0.473	0.45
2004	0.94	0.92				0.19	0.18			
2005	0.74	0.87				0.12	0.13			
2006	0.82	0.69				0.13	0.11			
2007	0.71	0.58				0.14	0.11			
2008	0.75	0.81				0.11	0.12			
2009	0.74	0.72				0.14	0.24			
2010	0.69	0.93				0.12	0.19			
AVE	**0.83**	**0.88**				**0.16**	**0.20**			

Notes: W.C. NWR = West Central Nutrient Watershed Region; WBID 1536C = Tampa Bypass Canal Tributary.

It is possible that these low nutrient levels are maintained in part through uptake by aquatic plants, such as algae. The chlorophyll data from Six Mile Creek does provide evidence of periodic algal blooms (see Figure 11 and Figure 19). However, the physical alterations that have been done to Six Mile Creek, including the deepening, widening, armoring and installation of flow-control structures that prevent the free-flow of water, have the effect of increasing surface heating and reducing re-aeration of oxygen at depth. Thus, the physical alterations appear to have more of an influence on dissolved oxygen concentrations than nutrient levels. Since the WBIDs downstream of Six Mile Creek are also impaired for DO, and since it is unlikely that Six Mile Creek will be able to maintain a daily average DO of 5 mg/l, given the alterations that have occurred to it, the TMDL analysis focused on ensuring that pollutant loadings from the Six Mile Creek watershed would not cause or contribute to DO impairment in the receiving waters of the tidal Palm River, McKay Bay and Hillsborough Bay system. This TMDL relies on the modeling analysis that was done to develop the TMDL for the Palm River (WBID 1536E) and McKay Bay (WBID 1584B). That analysis determined the natural pollutant loadings that would be expected from the watershed upstream of Structure 160, including the WBIDs addressed in this report, in the absence of anthropogenic pollutant loads. The analysis is described further in the following section.

7.2. Determination of Current and Natural Watershed Loads

A majority of the nutrient loading delivered to the Palm River and McKay Bay passes over Structure 160 on Six Mile Creek. This structure marks the divide between the freshwater segments of Six Mile Creek, and the tidal/marine waters downstream. Two main modeling scenarios were evaluated: one that simulated the watershed as it exists today (i.e. current condition), and one that simulated a natural pollutant-loading condition. Three different models were used in the development of the TMDLs to address nutrient and DO impairment in the Palm River (WBID 1536E) and McKay Bay (WBID 1584B) (USEPA, 2012b). The empirical watershed-loading model that was developed for the Nitrogen Management Consortium Reasonable Assurance Plan was used to predict current pollutant loadings of total nitrogen, total phosphorus, BOD, and chlorophyll emanating from watershed. These loads were input into an EFDC hydrodynamic model, and a WASP water quality model, in order to evaluate the impacts of these pollutant loads. The water quality model was calibrated to current conditions using measured data.

The current conditions scenario used recent land use information and measured meteorological conditions from the simulation period to predict the existing loadings of nitrogen, phosphorus and BOD from ungaged portions of the watershed. The primary tributary inputs were calculated using gaged flows and constituent concentrations measured at nearby water quality monitoring stations. Any point source contributions to the Palm River or Easy Bay were calculated from measured discharge volume and concentration data. The predicted water quality loadings and flow time series were passed on to the in-stream (WASP) water quality model, where algal, nitrogen, phosphorus, BOD and DO concentrations were predicted over time. The models were calibrated to a five year period of time to take into account varying environmental, meteorological or hydrological conditions on water quality.

The current condition simulation was used to estimate the existing loadings of TN, TP and BOD for Six Mile Creek (Table 6). These loadings were compared with the TMDL scenario to determine the reduction in nutrient loads that is needed to achieve water quality standards.

Table 6. Existing Condition Annual Average Nutrient Loads (2003-2007).

	Six Mile Creek to S-160	
Constituent	**WLA (lb/day)**	**LA (lb/day)**
Total Nitrogen	NA	582
Total Phosphorus	NA	182
BOD	NA	1,359

The second modeling scenario was developed over the same five year period to estimate what water quality conditions would exist if pollutant loads reflected natural, undisturbed land uses and there were minimal or no pollutants contributed by anthropogenic sources. There are no facilities permitted to discharge in the Six Mile Creek watershed above S-160 (although there are some facilities that discharge to the Palm River or to East Bay downstream of the area addressed in this TMDL). For the purpose of this analysis, any land use that is associated

with man induced activities (urban, agriculture, transportation, barren lands and rangeland) was converted to its native, undisturbed land use and the associated constituent concentration for nitrogen, phosphorus and BOD were used. Point source loads were also removed. These natural condition loadings from the watershed model were passed onto the water quality model in order to evaluate the improvement in DO. The purpose of the natural conditions scenario is to determine whether water quality standards could be achieved without abating the naturally occurring loads from the watershed. Simulation results indicated that the five mg/l daily average component of the DO standard is not achievable in either the Palm River or McKay Bay under natural nutrient and BOD loadings. Table 7 provides the annual average load predictions for TN, TP, and BOD in units of lb/day.

Table 7. Natural Condition Annual Average Nutrient Loads.

	Six Mile Creek to S-160	
Constituent	**WLA (lb/day)**	**WLA (lb/day)**
Total Nitrogen	NA	120
Total Phosphorus	NA	42
BOD	NA	412

Additional details about the model setup and calibration may be obtained in the TMDL report and its appendices.

8. TMDL Determination

The TMDL for a given pollutant and waterbody is comprised of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is represented by the equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving waterbody and still achieve water quality standards and the waterbody's designated use. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be set and thereby provide the basis to establish water quality-based controls. These TMDLs are expressed as annual mass loads, since the approach used to determine the TMDL targets relied on annual loadings. The TMDLs targets were determined to be the conditions needed to restore and maintain a balanced aquatic system. Furthermore, it is important to consider nutrient loading over time, since nutrients can accumulate in waterbodies.

During the development of this TMDL, it was determined that the natural condition scenario (removal of all anthropogenic sources and landuses) does not protect Florida standards for DO

downstream. The reductions prescribed in this TMDL reduce the current loadings to the natural condition loads. The allocations are provided in Table 8. These are the loads that need to be met at Structure 160- the point where Six Mile Creek flows into the tidal Palm River.

Table 8. TMDL Load Allocations for Six Mile Creek (WBIDs 1536F and 1536B).

	Current Condition		TMDL Condition		
Constituent	**Facility WLA (lb/day)**	**MS4/LA (lb/day)**	**Facility WLA (lb/day)**	**MS4/LA (lb/day)**	**Percent Reduction**
Total Nitrogen	NA	582	NA	120	79%
Total Phosphorus	NA	182	NA	42	77%
BOD	NA	1,359	NA	412	70%

Notes: The nutrient and BOD TMDLs are intended to be implemented on an annual basis. The average annual pounds per year should not exceed their equivalent annual values of 43,847 lb/yr TN, 15,221 lb/yr TP, and 150,399 lb/yr BOD. Daily variation above and below the daily loads is expected.

8.1. Critical Conditions and Seasonal Variation

USEPA regulations at 40 CFR 130.7(c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The critical condition is the combination of environmental factors creating the "worst case" scenario of water quality conditions in the waterbody. By achieving the water quality standards at critical conditions, it is expected that water quality standards should be achieved during all other times. Seasonal variation must also be considered to ensure that water quality standards will be met during all seasons of the year, and that the TMDLs account for any seasonal change in flow or pollutant discharges, and any applicable water quality criteria or designated uses that are expressed on a seasonal basis.

The critical condition for nonpoint source loadings and wet weather point source loadings is typically an extended dry period followed by a rainfall-runoff event. During the dry weather period, nutrients build up on the land surface, and are washed off by rainfall. The critical condition for continuous point source loading typically occurs during periods of low stream flow when dilution is minimized. Although loading of nonpoint source pollutants contributing to a nutrient impairment may occur during a runoff event, the expression of that nutrient impairment is more likely to occur during warmer months, and at times when the waterbody is poorly flushed. Because the five year simulation period used in the model development represents a range of wet and dry years, the model encompasses both critical conditions and seasonal variations to determine the annual average allowable load.

8.2. Margin of Safety

The Margin of Safety accounts for uncertainty in the relationship between a pollutant load and the resultant conditions of the waterbody. There are two methods for incorporating an MOS into TMDLs (USEPA, 1991):

- Implicitly incorporate the MOS using conservative model assumptions to develop allocations
- Explicitly specify a portion of the total TMDL as the MOS and use the remainder for Allocations

The Six Mile Creek TMDL incorporates an implicit margin of safety by capping the TMDL loads to natural background conditions, with no anthropogenic inputs.

8.3. Waste Load Allocations

Only MS4s and NPDES facilities discharging directly into lake segments (or upstream tributaries of those segments) are assigned a WLA. The WLAs, if applicable, are expressed separately for continuous discharge facilities (e.g., WWTPs) and MS4 areas, as the former discharges during all weather conditions whereas the later discharges in response to storm events.

8.3.1. Wastewater/Industrial Permitted Facilities

There are no NPDES-permitted facilities with direct, surface water discharges within the Six Mile Creek watershed. Therefore, no WLA was allocated for such facilities.

8.3.2. Municipal Separate Storm Sewer System Permits

The WLA for MS4s are expressed in terms of percent reductions equivalent to the reductions required for nonpoint sources. Given the available data, it is not possible to estimate loadings coming exclusively from the MS4 areas. Although the aggregate wasteload allocations for stormwater discharges are expressed in numeric form, i.e., percent reduction, based on the information available today, it is infeasible to calculate numeric WLAs for individual stormwater outfalls because discharges from these sources can be highly intermittent, are usually characterized by very high flows occurring over relatively short time intervals, and carry a variety of pollutants whose nature and extent varies according to geography and local land use. For example, municipal sources such as those covered by this TMDL often include numerous individual outfalls spread over large areas. Water quality impacts, in turn, also depend on a wide range of factors, including the magnitude and duration of rainfall events, the time period between events, soil conditions, fraction of land that is impervious to rainfall, other land use activities, and the ratio of stormwater discharge to receiving water flow.

This TMDL assumes for the reasons stated above that it is infeasible to calculate numeric water quality-based effluent limitations for stormwater discharges. Therefore, in the absence of information presented to the permitting authority showing otherwise, this TMDL assumes that water quality-based effluent limitations for stormwater sources of nutrients derived from this TMDL can be expressed in narrative form (e.g., as best management practices), provided that: (1) the permitting authority explains in the permit fact sheet the reasons it expects the chosen BMPs to achieve the aggregate wasteload allocation for these stormwater discharges; and (2) the state will perform ambient water quality monitoring for nutrients for the purpose of determining whether the BMPs in fact are achieving such aggregate wasteload allocation.

All Phase 1 MS4 permits issued in Florida include a re-opener clause allowing permit revisions for implementing TMDLs once they are formally adopted by rule. Florida may designate an area as a regulated Phase II MS4 in accordance with Rule 62-620.800, FAC. Florida's Phase II MS4 Generic Permit has a "self-implementing" provision that requires MS4 permittees to update their stormwater management program as needed to meet their TMDL allocations once those TMDLs are adopted. Permitted MS4s will be responsible for reducing only the loads associated with stormwater outfalls which it owns, manages, or otherwise has responsible control. MS4s are not responsible for reducing other nonpoint source loads within its jurisdiction. All future MS4s permitted in the area are automatically prescribed a WLA equivalent to the percent reduction assigned to the LA.

Hillsborough County, District 7 of the Florida Department of Transportation and other co-permittees are covered under Phase I MS4 permit FLS000006, which encompasses the majority of the watershed draining to the impaired WBIDs. Small portions of the individual Phase I MS4 permits held by the City of Tampa (FLS000008) and the City of Temple Terrace (FLS000009) may also encroach upon the watershed. Stormwater discharges conveyed through the storm sewer systems covered by these permits, and discharged within the Six Mile Creek watershed, are subject to the WLA of the TMDL. Permitted MS4s will be responsible for reducing only the loads associated with stormwater outfalls which it owns, manages, or otherwise has responsible control. MS4s are not responsible for reducing other nonpoint source loads within its jurisdiction. Best management practices for the MS4 service should be developed to meet the percent reduction targets in Table 8.

8.4. Load Allocations

The load allocation for nonpoint sources is expressed as the annual loads of BOD, TN and TP that would need to be maintained at the watershed outlet. The associated percent reduction in current loadings that would be needed to meet the TMDL loads is also provided.

9. Recommendations/Implementation

This TMDL is based on mechanistic modeling of the dissolved oxygen and eutrophication processes using available meteorologic data, hydrologic data, stream geometry, water chemistry data and the evidence of low reaeration, high detrital loading, strong photosynthetic activity, and SOD. The lack of SOD measurements, reaeration measurements, aquatic macrophyte and periphyton measurements introduces uncertainty into this TMDL. Collection of these additional data will help reduce uncertainty and better assess the contribution of potential sources, the timing of any water quality exceedances, and necessary reductions.

Since the TMDL analysis indicates that neither Six Mile Creek, nor its receiving waters, will meet their applicable DO standards, even under natural pollutant loadings, EPA encourages the development of site-specific water quality standards for DO.

The initial step in implementing a TMDL is to more specifically locate pollutant source(s) in the watershed. FDEP employs the Basin Management Action Plan (B-MAP) as the mechanism for developing strategies to accomplish the specified load reductions. Components of a B-MAP are:

- Allocations among stakeholders
- Listing of specific activities to achieve reductions
- Project initiation and completion timeliness
- Identification of funding opportunities
- Agreements
- Local ordinances
- Local water quality standards and permits
- Follow-up monitoring

10. References

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Florida Administrative Code. Chapter 62-302, Surface Water Quality Standards.

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